Alternative Energy Resources
Unit On Wind Energy

John DiFiore
Cassidy School

Overview:
The topic of Energy Resources is and will be in the future, at major topic interest not only for elementary science curriculum but for the general public as well. The basis for understanding the far-reaching aspects of this topic need to be addressed in the elementary grades in order for students to be prepared for the future. Currently the School District of Philadelphia addresses, the topic of Solar Energy with a twelve-week unit for 5th grade. I believe the insertion of 4 to 5 lessons providing background knowledge and hands on activities on the topic of Alternative Energy Resources would be an appropriate and necessary addition to our current curriculum.

Rationale:
As a science specialist teacher, I teach every class for one 45-minute lesson weekly. The lessons must be concise, engaging, as well as informative in order to have carry over to the next week and beyond. My students are residents of West Philadelphia and come from a lower to middle income background. Generally, they enjoy coming to science class and are anxious to "get their hands on" something other than a pencil and paper. I have found that the use of high quality videos, with sufficient background knowledge given before hand, and follow up after viewing, an effective tool in giving students as well as myself, the "Big Picture" and valuable background knowledge on many topics. Participating in hands-on activities helps in connecting Science to Math, Reading/Language Arts and Social Studies. Students are much more receptive to doing research, making tables, graphs, or charts, performing calculations, and writing about what they have learned after experiencing a hands-on lesson. I have participated in many Science workshops during the last thirteen years I have been a science specialist teacher.

I have found that I, as most elementary school teachers, have a limited science background. Doing research though the TIPS course has given me valuable background information to assist me in the design of my lessons, and just as important, what is inappropriate or unnecessary for a 5th grade student. I hope my students will gain real life insights to the topic of Alternative Energy Resources though focused background knowledge research and real life hands – on science lessons which will be informative memorable and fun.

Objectives:

The students will be able to do the following:

- Identify sources of renewable and non- renewable energy resources
- List latest worldwide energy consumptions by source
- Define basic vocabulary related to the topic of energy
- Explain basic formulas related to energy and their uses
- Discuss global implications energy issues have on the future
- Recognize effects energy dependence has on every day life
- Work cooperatively in small groups
- Identify questions, design and conduct scientific investigations to answer those questions
- Develop process skills through hands on activities such as observing, classifying, inferring, controlling variables, collecting data, predicting, communicating, making comparisons, analyze and interpret data,

Strategies:

Students will be given basic background knowledge though handouts and short lectures as an introduction to each lesson. My hope is to develop activities using basic science equipment and inexpensive materials. These activities will illuminate fundamental energy concepts, which can be related to the background knowledge given, and to the students every day lives. The students will work in small groups of 4-6, and will be evaluated on their classroom performance through informal teacher observation of: following directions, handling equipment, working cooperatively with others. Students will complete written responses to guided questions on a daily "Do Now" paper. Students will be given the opportunity to "report out" orally. Students will complete a student survey.

Background Information

Non-Renewable Energy Resources - Fossil Fuels

Coal

Coal is a shiny black rock that has lots of energy in it. People in the past used coal to cook and heat homes. Coal burns longer than wood so it did not need to be collected as often. In the 1800s coal was used as fuel by trains and boats, and in factories to make steel. Today coal is used mainly to make electricity.

Coal was formed millions of years ago before the dinosaurs, it was formed when thick layers of plants died and sank into swamps. They were packed down by the weight of dirt and water and after millions of heat and pressure the plants changed into coal. This is why coal is called fossil fuels. The energy from coal comes from the Sun. Since coal was formed from plants and plants get their energy from the sun. Since it took millions of years for coal to form, we can't make more of it in a short amount of time. That is why coal is non-renewable.

The United States has more coal than any other country in the world. Coal is mined in 26 of the 50 states. Burning coal produces half of the power used in the U.S.
There are 4 kinds of coal:

- Anthracite – "Hard coal" which gives off a great amount of heat. There is a limited supply, mined mainly in Pennsylvania.
- Bituminous – "Soft coal" – mined mostly east of the Mississippi river
- Subbituminious – Dull black coal mined mostly in Montana and Wyoming
- Lignite – Makes up most of the worlds coal, mined mostly west of the Mississippi river

Because coal is abundant in the United States it is an inexpensive way to produce electricity. There is enough coal in the U.S. to last for more 250 years. However because coal is burned impurities trapped inside of coal are released into the air and when combined with water vapor form what scientist call "acid rain". Coal burning also produces carbon dioxide a gas that in the earth's atmosphere is one of several gases that can trap the earth's heat. Scientists believe this is causing the earth's temperature to rise causing the "greenhouse effect".

Today, we have the technology that can filter out 99% of the tiny particles and remove 95% of the "acid rain" pollutants. Scientists are also developing ways to gasify coal into carbon monoxide and hydrogen gases so it can be used without burning. (www.fossil.energy.gov.education/enegylesson/coal/index/html p.1-8)

Oil

Oil is another fossil fuel found in side the earth's crust. It is found in many part of the world. The oil in the ground is trapped between rocks called pores, in the form of tiny droplets. Oil reserves are not large underground lakes. Oil must be moved through dense rock into wells so that it can be taken to the surface. Natural forces of the earth do most of the work when a well strikes oil. Thousands of tons of pressure from the weight of the earth and the natural heat from inside the earth expands gases which force the oil into the well and is then force to the surface. Oil wells can produce for years. When the earth's natural pressure begins to drop oil companies eject gas back into the well to more oil out. Eventually the well stops producing however, for every barrel of oil that is recovered through the well 3 barrels are left behind. Scientists are developing several methods of

recovering the oil that is left behind. Of the 195 billion barrels of oil recovered in the U.S. 400 billion barrels have been left in the ground.
(www.fossil.energy.gov.education/lessons/oil/index.html p.1-5)

Natural Gas

Natural gas is made up of odorless colorless chemical called Methane. This gas is highly flammable and burns so completely that there is very little air pollution. Natural gas is most important in the U. S. for home heating and cooking. It accounts for nearly half of the energy used for these purposes and one-fifth of all the energy in the U.S. The rotten egg odor from natural comes from a chemical added in order to help in the detection of leaks. Leaks can be dangerously explosive and natural gas is odorless. The United States and Canada have large amounts of natural gas. There is enough to last for at least the next 60 years at present usage levels.

Natural gas was originally used in the 1800s as fuel for streetlights. Robert Bunsen invented the "Bunsen burner" in 1825. The Bunsen burner mixes air with natural gas. This demonstrated how natural gas could be used in a variety of ways. Natural gas is easy to transport from one location to another through pipelines. Most gas pipelines were not built in the U.S. until after World War II. Construction continued through out the U.S. through the 50s and 60s.

To get natural gas from where it is located in the earth's crust, wells are dug on some locations where gas is naturally forced to the surface from underground reservoirs. In many locations natural gas and oil may be pumped from the same location. Another method of bringing gas to the surface is by hydraulic fracturing. In this method drillers force water with sand or salt added to crack rock (usually shale, sandstone, and coal) open so that gas can flow. Scientists are also studying a type of gas called methane hydrates. These are found in deep ocean beds or in the colder regions of Alaska and Russia. This type of gas is formed in tiny cages of ice. Some researchers believe that some natural gas pockets may be found deep within the earth's surface. Their theory is that these pockets may have been formed during the creation of the earth.
(www.fossil.energy.gov/education/energylessons/gas/index/html p.1-4)

Nuclear

Nuclear energy is energy that is obtained from the energy stored in atoms. A process called Fission obtains this energy. In this process atoms split apart from bigger atoms, which releases energy. All the nuclear power produced in the U.S. is used for electricity.

Uranium, a common metal found in rocks all over the world is the nonrenewable fuel used in nuclear fission. Although common, uranium 235, the type used because the atoms are easily split, is rare. In 2008 53 million pounds of uranium was used in the U.S. 14%

was mined in the U.S. 86% was imported. This fuel is used in fission produces a chain reaction where small particles called neutrons hits the uranium and releases heat and radiation energy. The process repeats itself over and over. The steam/water is cooled in a cooling tower to be reused.

Although nuclear power emits no carbon dioxide or air pollution, large amounts of energy are needed to mine and refine uranium as well as building the power plant. The major environmental concern with nuclear energy is with radioactive waste, and the possibility of an accident within the reactor/power plant resulting in an uncontrolled reaction. An accident could result in widespread contamination of air and water for hundreds of miles around the reactor. Nuclear waste can be classified as low or high level. The danger of nuclear waste decreases over time. Low-level waste is usually buried in the ground near the power plant site and the contamination level will dissipate over many years. High-level waste is stored in special concrete or steel containers to avoid contamination and buried. There is currently no permanent disposal facility for high-level nuclear waste in the U.S. The storage of radioactive waste as well as the operation of nuclear power plants is governed by the U.S. Nuclear Regulatory Commission. (www.eia.doa.gov/kids/energy.cfm?page=nuclear_home_basics p.1-3)

Renewable Energy Sources

Renewable energy sources can be sustained indefinitely. In 2008 about 7% of all energy in the U.S. came from renewable sources. Half of this energy goes to the production of electricity. Renewable sources of fuel (non-biomass) do not contribute directly to the production of greenhouse gasses. The most common of these sources are: Biomass Water Geothermal Wind and Solar.

Solar

"The most available and democratic source of renewable energy on the planet is solar energy". ("Renewable Energy Sources for the Vertical Farm" Cujar, Hettrich, Kellogg, Mantilla p.3) Solar energy can be used for heat and electricity. Two methods of obtaining solar energy are Thermal Collectors and Photovoltaic Cells.

Solar thermal devices use direct heat from the sun, concentrating it in some manner to produce heat at a useful temperature. (http://tonto.eia.doe.gov.energyexplained/index.cfm?page=solar-renewable_home p-1 Thermal collectors can be classified as passive or active. Passive collectors use no mechanical equipment and are used in buildings using heated air from the sun. Circulated air passes a solar heat surface though convection. Active collectors require a collector to absorb and collect solar radiation. Fans or pumps are used to circulate the heated air or heat absorbing fluid. Solar collectors are either no concentrating or concentrating. No concentrating cells are most often used for heating buildings. These "flat-plate" collectors are used when temperatures are below 200 degrees. This type intercepts the solar radiation and the area needed is the same as the absorbing area. Concentrating collectors use much greater intercepting area than absorber area. (http;//tonto.eia.doa.gov.energyexplained/index.cfm?page=solar-renewable_home p.2)

Solar thermal collectors are divided into low-medium and high temperature collectors Low temperature collectors<110 degrees provide heat and are used for low-grade water and space heat for residential use. Medium temperature collectors, usually 140-180 degrees, are mainly used for domestic hot water heating. High temperature collectors operate above 180 degrees and are used mainly by utilities to generate electricity. (http://tonto.eia.doe.gov.energyexplained/index.cfm?page=solar-renewable_home p.4)

Photovoltaic Cells (PV) cells are non-mechanical devices that turn the sun's energy directly into electricity. These cells are made from silicon, which is the major ingredient in sand. When chemicals are added to each side of the cell, they work together to change the sun's energy into electricity the cells allow photons (particles of the sun's energy) to be absorbed providing energy to generate electricity. (www.need.org) Cells can vary in size from 0.5 to 4 inches across. They are then connected into an array the number of which is determined by the amount of power output needed. Photovoltaic systems range from small; those used in calculators to larger more complicated systems used in electricity to pumping water, power communications equipment and provide electricity for homes.1 (http://tonto.eia.doe.gov.energyexplianed/index.cfm?page=solar-photovaltaics_home p.1)

Drawbacks to solar energy are: The amount of sunlight is not constant. Large surface areas are needed to collect enough energy to be used at a useful rate. The cost of solar power stations is expensive.

Water

Hydropower is energy obtained by moving water. This type of power accounts for 6% of all electrical power in the U.S. and 67% of all renewable sources. (http://tonto.doe.gov.energyexplained/index.cfm?page=hydropower_home) Energy from moving water is determined by its flow or fall. When the movement of water pushes against a turbine to spin generator electricity can be produced. Most hydroelectric power in the U.S. is produced in four western states; Washington Oregon. California, and Montana.

Water movement made by Tides also produces energy. Dams known as barrages placed across inlets allow gates to control the flow of water on incoming and outgoing tides. However there are currently no barrages operating in the U.S. Tidal Turbines are located where strong there is strong water flow. There are 6 tidal turbines located in the East river of New York City. (http://www.sciam.com/article.cfm?id=tidal-wave-renewable-energy p.3)

Wave power is caused by wind blowing over the surface of the ocean. Many methods of channeling this power source are currently under development. Wave farms, which place devices anchored under the water and others on top of the water, are being used in Portugal. See all the technologies under development at the U.S. Department of energy's Marine and Hydrokinetic Technology Database.
(http://www.sciam/com/article.cfm?id=tidal-wave-renewable-energyp.5)

Hydropower while nonpolluting does effect the environment. Dams, reservoirs and hydroelectric power plants can displace people from their homes, change river temperature and flow, harm native plants, and obstruct fish migration. Methane may also form in reservoirs and be emitted into the atmosphere. The cost of dams is also a disadvantage.

Biomass

Biomass is renewable energy source made of organic material from plants and animals. Chemical energy from substances such as wood, crops, manure, and some garbage is released when burned. These substances may also be converted into energy in the forms of methane gas, ethanol, or biodiesel. Ethanol and biodiesel fuels are usually blended with petroleum fuels but can also work on their own, and are cleaner burning fuels. Ethanol is a fuel made from the sugars found in crops such as corn, sorghum, barley, potato skins, rice, sugar cane, and sugar beets. It can also be found in yard clipping, bark and switch grass. Gasoline powered engines may use gas mixed with 10% ethanol (E10) of which 99% of ethanol produced in the U.S. is made. Some specially made vehicles may use (E85) 85% ethanol and 15% gasoline. The fastest growing alternative fuel in the U.S. is Biodiesel. Biodeisel is made from vegetable oils, fats, or greases found in recycled restaurant grease. Biodeisel is biodegradable, produces lower levels of pollution and is renewable. Only 4% on the energy in the U.S. is provided by biofuels.

Methane gas is produced when organic materials decompose. Landfills are a source for the production of methane gas. There are over 400 gas – energy landfill production plants in the U.S. Another way of obtaining methane is from farms. Farmers accumulate animal waste and place it in tanks called "digesters" and are able to separate gas from the waste. (http://tonto.eia.doe.gov/energyexplained/index.cfm?page=biomass-renewable_home p.1-4)

Wind

Wind energy is mainly used to generate electricity Wind is a renewable energy source because the wind blows as long as the sun shines. About 1 to 2 per cent of the energy coming from the sun is converted into wind energy. 'Workshop for Renewable Energy"- "Wind Energy" Wind turbines use blades to collect the kinetic energy of the wind. Much like windmills, air flows over the blades creating lift, which make them turn. The blades are connected to a drive shaft that turns an electric generator to produce electricity. (http://tontoeia.doa.gov/kids/energy.cff?page=wind_home-basic) A wind farm is a collection of wind turbines in the same location. (Investigating Renewable Energy, Rowley, MA p.48-49) Only a small amount of our nations electrical energy comes from the wind (less than 2%). Placement of wind power stations is of major concern. Areas must be in open such as shorelines or hills, with no windbreaks. Wind turbines are located in 31 different states and the U.S. ranks first in the world in wind power capacity.

There are two types of wind turbines, horizontal-axis (windmill) and vertical–axis (egg beater). The size of the wind machines can vary from the small single home variety to large turbines that are often grouped together in wind farms to make power for the electrical grid. The next generation horizontal-axis wind turbine currently being developed for use off shore by General Electric is planned to go line in 2012. It is 40% longer than the average blade (176feet) and will stand 300 feet out of the water. (Popular Science, April 2010 p.42 -43)

Disadvantages to wind power are: wind can be unpredictable, turbines can be noisy, turbines kill birds, and wind farms can be unsightly. (Investigating Renewable Energy, Rowley, MA p.52)

Geothermal

Is energy that is heat from within the Earth. We can recover this as steam or hot water and use it to heat buildings or generate electricity. Geothermal energy is a renewable energy source because the heat is continuously produced inside the Earth. Magma, very hot melted rock comes to the Earth's surface near the edges of the Earth's plates. This heat flux tends to be strongest along tectonic plate boundaries where volcanic activity transports high temperature material to near the surface. However even in parts of the world far from plate boundaries, there can still exist areas of higher than average natural heat flow. Deep underground rocks and water absorb heat from magma, the deeper underground you go the hotter the rocks and water gets. By digging deep wells and pumping the heated underground water or steam to the surface geothermal energy is used to heat homes and produce electricity. Direct use and heating applications of geothermal energy have almost no impact on the environment. Geothermal power plants do not burn fuel to generate electricity so their emission levels are very low. They release less than 1% of the carbon dioxide emissions of a fossil fuel plants. Geothermal plants emit 97% less acid rain-causing sulfur compounds than are emitted by fossil fuel plants. (http;//www.eia.doe.gov/kids/energy/crm?page=geothermal_home-basic#geothermal p.1-3) Newer geothermal energy plants can make electricity for about the same cost as coal plants. Scientific research showing us how to tap into geothermal energy has already been accomplished. However little has been done to advance this research. (http://www.magma-power.com p.1-4)

Batteries

According to the U.S. Energy Information Administration: a battery produces electricity using two different metals in a chemical solution. A chemical reaction between the metals

and the chemicals frees more electrons one metal than in the other. One end of the battery is attached to one of the metals; the other end is attached to the other metal.
The end that frees more electrons develops a positive charge and the other end develops a negative charge (.http :tonto.eia.doe.gov/energyexplained/index.cfm?=electricity-batteeries) This forms an electric circuit from which electricity can do work. The ideal battery would have no mass, no volume no cost, infinite voltage, and infinite life. (“Batteries” workshop on “Physics for Renewable Energy”)

Lithium ion batteries are the power choice for portable electronics such as cell phones PDAs and laptops. Several million are produced each year in a variety of shapes and sizes. Lithium ion battery technology relies on cell configuration of two intercalation electrodes in a layer.

In order for batteries to be an effective tool in combating carbon emotions in cars low cost high energy batteries are needed for efficient electric or hybrid car operation. Nickel-metal hydride batteries are currently used as storage units for cars that run on both gas and electricity. A recent development, which could have an impact on cutting down the production of carbon emissions, is the development of a solid oxide battery called Blooms’ Box. This devise converts fuel into electricity through clean electo-chemical process rather than combustion. They are like batteries except they always run. Biogases or natural gas are used to operate this “Energy Saver”, which is able to capture the exhaust generated by the heat produced and recycle it within the cell. Trials have shown Bloom’s Box to be 35 to 40% more efficient than solar energy.
www.bloomenergy.com/products/what-is-an-energy-server/

Global Warming
The greenhouse effect is the result of heat absorption by certain gases in the atmosphere (called greenhouse gases because they effectively ‘trap’ heat in the lower atmosphere) and re-radiation downward of some of that heat. Water vapor is the most abundant greenhouse gas, followed by carbon dioxide and other trace gases. Major gases emitted in the U.S. as a result of human activities are: Methane, Nitrous oxide (N2O), Industrial gases, Hydro fluorocarbons (HFCs) Perflourocarbons (PFCs), Sulfur hexafluoride (SF6). The concern about the greenhouse effect is whether human activities are enhancing this effect by the emission of greenhouse gases through fossil fuel combustion and deforestation.
(http://www.ncde.noaa.gov/oa/climate/globalwarming.html) Energy related carbon dioxide account for 81.3 % of human-caused greenhouse gas emissions.

Without a natural greenhouse effect, the temperature of the earth would be much lower than its present temperature of 57°F. If not for the natural greenhouse effect the earth’s temperature would be about 2°F. There is no scientific debate on the question of whether or not human activity has been responsible for increasing the level of greenhouse gases. Global concentrations of CO_2 far exceed the natural range over the last 650,000 years. Surface temperature trends have increased in the past 50 years by 0.13C. This is nearly twice that for in the last 100 years although not globally uniform.

Paleoclimatic data has been critical in developing a picture beyond the range of instruments. Natural phenomenon such as tree growth, ice cores, lake and ocean sediment, which is climate dependant in the reconstruction of past climates. The combination of this and instrumental data enables scientist to develop a current picture of the Northern Hemisphere that is the warmest in the last 1000 years since the late 19^{th} century. Ozone is technically a greenhouse gas because it has an effect on global temperature. However, at higher elevations in the atmosphere (stratosphere), where it occurs naturally, it is needed to block harmful UV light. At lower elevations of the atmosphere (troposphere), it is harmful to human health and is a pollutant regulated independently of its warming effects. (www.globe.gov/fsl/html/templ.cgl?elemglobe)

Vocabulary Terms - List

Alternative Energy Resources
Anemometer - a devise for measuring wind speed
Energy – the ability to do work
Types of energy – Potential – stored energy
Kinetic – energy in motion
Forms of energy – Heat (thermal)
Light (radiant)
Motion (kinetic)
Electrical
Chemical
Nuclear
Gravitational
Law of Conservation of Energy – energy can neither be created nor destroyed. We change energy from one form to another. The total amount of energy in the universe stays the same.
Energy Efficiency – the amount of useful energy gained from any type of system
Fossil Fuels – fuels formed from buried remains of plants and animals that lived millions of years ago
Formulas:
Work = force distance
Power = energy divided by time (the rate at which work is performed or energy is transmitted)
Energy = power x time (work done to produce power over a period of time)
Wind Power = velocity3
Non-Renewable Energy Sources – energy sources that cannot be replenished in a short period of time

Photovoltaic Cell – solar cell or PV- a non-mechanical cell that converts the sun's energy directly into electricity
Renewable Energy Sources – energy sources that can be replenished naturally in short period of time
Technology – the products and processes created by engineers
Thermal - heat
Tunnel Effect – the air becomes compressed on the windy side of the building or mountains and its wind velocity increases
Turbine – a devise in which blades are turned by force (wind, water, or steam pressure). The mechanical energy of the spinning turbine is converted into electricity by a generator.
Pitch – angle of blades on a wind turbine

CLASSROOM ACTIVITIES

This Unit is intended to be a follow up to the Solar Energy unit required by the school district of Philadelphia. It will also serve as a lead in to the next unit required by the School District on Variables. In each lesson background material on Energy sources Renewable and non-renewable/alternative will be covered. Basic Physics formulas related to energy will be addressed as they arise. The EiE (Engineering is Elementary) design process will be integrated into lessons where appropriate. Engineering is Elementary is a national program that has created elementary level engineering units that link to national standards.

EiE engineering design process steps and description.

Ask	Identify the problem Determine design constraints (e.g., limitations on materials that can be used). Consider relevant prior knowledge (e.g. science concepts).
Imagine	Brainstorm design ideas. Draw and label those ideas
Plan	Pick one idea. Draw and label the idea Identify needed materials or conditions
Create	carry out the plan; create the design Test the design.
Improve	Reflect on the testing results Plan for, create, and test a new (improved) design

www.mos.org/eie

Portions on blade/windmill design, general management and setting up activities were adapted from the article “Engineering for All”(Science &Children March 2010 vol.47 Number 7)

Lessons/materials adapted from WindWise Education will also be used. Windwise is a comprehensive Wind Energy curriculum that includes a set of interdisciplinary lessons in an easy-to-use format. It uses an inquiry-based format to encourage creative thinking and hands –on activity to develop analytical skills. Some materials purchased from WindWise Education may be used to create the windmills built by students in the lessons. www.WindWiseeducation.org

LESSON 1 – INTRODUCTION

Objective: Students will identify renewable and non-renewable energy sources by making a KWL list. Basic energy concepts/definitions: energy, work, force, power, Law of Conservation of Energy, potential and kinetic energy, will be demonstrated by using magnets, flashlights, tuning forks, and pinwheels.

Materials/Resources

Energy Vocabulary List

Energy Kids Sources of Energy-U.S Energy Consumption by Source, 2008 hand out

Flashlight, Magnets, Tuning Forks, Pinwheels

Student Grouping

Whole Class

Prior Knowledge Assessment

In this lesson we will review the use of Solar Energy discovered in the previous unit and find out what we know about all other forms of energy and their sources by the use of a KWL chart. Answers will be charted into Renewable and Non-renewable categories. Definitions of energy, work, and force along with their formulas and the law of Conservation of Energy will be discussed.

- Identify/review Solar Energy as a renewable energy resource
- List/chart student awareness of Renewable and Non-Renewable energy resources identify aspects of each, include any not listed

Teaching Strategies/Demonstration/Activity/Explanations

- Student will brainstorm ways to move a crumbled piece of paper place on the lab table without touching it.
- Hand out Energy Vocabulary List introduce/review basic energy vocabulary as they arise
- Though demonstrations and activity the following concepts will be identified
- Law of the Conservation of Energy-energy cannot be created or destroyed, although it can be changed from one form to another
- Energy – the ability to do work
- Work- when a force acts to move an object
- Force-a push or a pull

- Power-time rate at which work is done
- Potential energy- stored energy
- Kinetic energy- energy in motion
- Hand out U.S. Energy Consumption by source, 2008 (EIA, Annual Energy Review 2008) Discuss aspects of each source
- Demonstrate heat energy (fire) sound energy (tuning fork) potential energy (battery) kinetic/light energy (flashlight) force (blowing a pinwheel) magnetic energy (magnets)

Closure

Students will complete their "Do Now" Activity paper, which has student list the objective and activity title at the beginning of each class and answer the questions What did I do? What did I observe? What do I think it means?

Assessment

Student may report out answers on their "Do Now" papers

LESSON 2 - HOW DOES A WINDMILL WORK?

Objective: Students will begin to answer the question "How can we get the wind to do work"? By listening to excerpts from books, and looking at pictures from books and the Internet, which illustrate wind energy at work, Students will make drawings and build a windmill system which can do work.

Materials/Resources

Books: "Energy Forever? Wind Power" by Ian Graham Show
"Alternative Energy wind Energy" by Graham Rickard

Pictures from www.nrel.gov/data/pix/searchpix.phd

Data recording paper

Student Grouping

Small groups of 5/6

Styrofoam balls, wooden dowels, cardboard container (cylinder, large oatmeal box) oak tag, tongue depressors, construction paper (for blades) string, cups (bucket), pennies or washers as weights, scissors, glue or tape to attach blades to dowels, box fans for wind source

Prior Knowledge Assessment

Review previous lesson by eliciting student responses from their "Do Now" paper.

Teaching Strategies/Demonstrations/Activities/Explanations

Read selections on wind power history and show pictures from "Energy Forever? Wind Power" by Ian Graham Show and "Alternative Energy Wind Energy" by Graham Rickard. Pictures from the Internet www.nrel.gov/data/pix/searchpix.phd

This will begin to help us answer the "Big Question" How can we get the wind to do work? After looking and listening to excerpts from the books and looking at the internet pictures of various types of windmills used around the world, Students will look at the windmill making materials, begin to brainstorm ideas and make drawings of different types of blades. The basic windmill design will be the same. Material for windmill; Styrofoam balls, wooden dowels, cardboard container (for tower) oak tag, tongue depressors, or construction paper (for blades) string, cups, pennies or washers for weight, box fan for wind source. (Make sure the center of the fan matches up with the center of the windmill.)

Windmill design: Attach pre-made blades (using desired materials) on to dowels with tape or glue in a circular pattern around the Styrofoam ball. Insert a longer dowel through the tower directly behind the direction of the wind source and into the back side (opposite of wind source) of the Styrofoam ball. Attach one end of string on to the back of dowel, the other through either side of the top of a cup (bucket), tying the string over the center of the cup (bucket). This should allow the motion of the blades to turn the dowel and twist the string to pull the cup (bucket) to the top of the dowel.

Students will begin to assemble their blades and windmills. Students will test how their blade designs spin and make any adjustments. They will attach the cups (bucket) to test how much weight their windmill will lift. Students will do as many trials as time will allow and record their data.

Monitoring Student Progress

Informal observation and coaching during group work

Closure/Assessment

Student will complete their "Do Now" and data record papers and report successes and/or failures.

LESSON 3 - WHICH BLADES ARE BEST?

<u>Objective:</u> Students will build and test windmill blades, accounting, for variables such as size, number of blades, pitch, material, shape, blade surface and drag. They will record performance differences as variables are tested.

Materials/Resources

Previously made windmills and blades box fans

Data record paper

Protractor to measure the pitch

Internet pictures of windmills

Student Grouping

Small Group of 5/6

Prior Knowledge Assessment

Teaching Strategies/Demonstrations/Activities/Explanations

As student report a "Variables" chart will be compiled identifying the factors affecting their windmill. Factors not identified by students will be presented and listed for their consideration as they make adjustment to their blades. Students will have the opportunity to look at other groups' data on the amount of weight that was lifted during the previous class. They will look at possible design changes that will enhance the amount of weight their windmill is able to lift. Drag is the slowing down of the blades due to poor design or poor blade surface. Efficient blades are a key part of generating power. Sloppy or poorly made blades will never make enough energy to power anything. http;//www.kidwind.or

Possible variables:
Pitch- angle of the blades (dramatically affects power output)
Blade number- use 2 3 or 4 blades
Blade size- extend or shorten blades bigger is not always better
Blade surface- smooth surface = less drag
Blade shape- attention to the ends is critical heavy tips= more drag
Materials will be available for students to make new blades or make adjustments on used blades. As data is presented focus will be on the meaning of work and power.
Monitoring Student Progress
Informal observation and coaching during group work

Closure
Students will complete “Do Now” paper and complete their data sheet
Assessment
Student groups will report out their results

LESSON 4 - WIND POWER
Objective: Students will discover the power of the wind by setting up a wind tunnel and discover how wind velocity affects wind power (Wind power =velocity3) they will record how the power of the wind affects the amount of output of their windmill.
Materials/Recourses
Milk cartons or paper towel tubes, glue
Previously made windmills, box fans
Student grouping
Small groups of 5/6
Prior Knowledge Assessment
Students will analyze previous lessons’ variables and will try to answer the question: How can we get more power?
Teaching Strategies/Demonstrations/Activities/Explanations
Introduce the formula for wind power (wind power=V3) Students will discover that in a wind tunnel compressed air will increase wind speed, thus increasing the amount of power.
Students will make a wind tunnel by building a honeycomb out of milk cartons or paper towel cylinders and placing it in front of the wind source. Student will test the effects of the tunnel on the amount of weight their windmill will lift. They will compare their data from the wind tunnel tests and previous test and make conclusions.
Monitoring Student Progress
Informal observation and coaching during group work
Closure

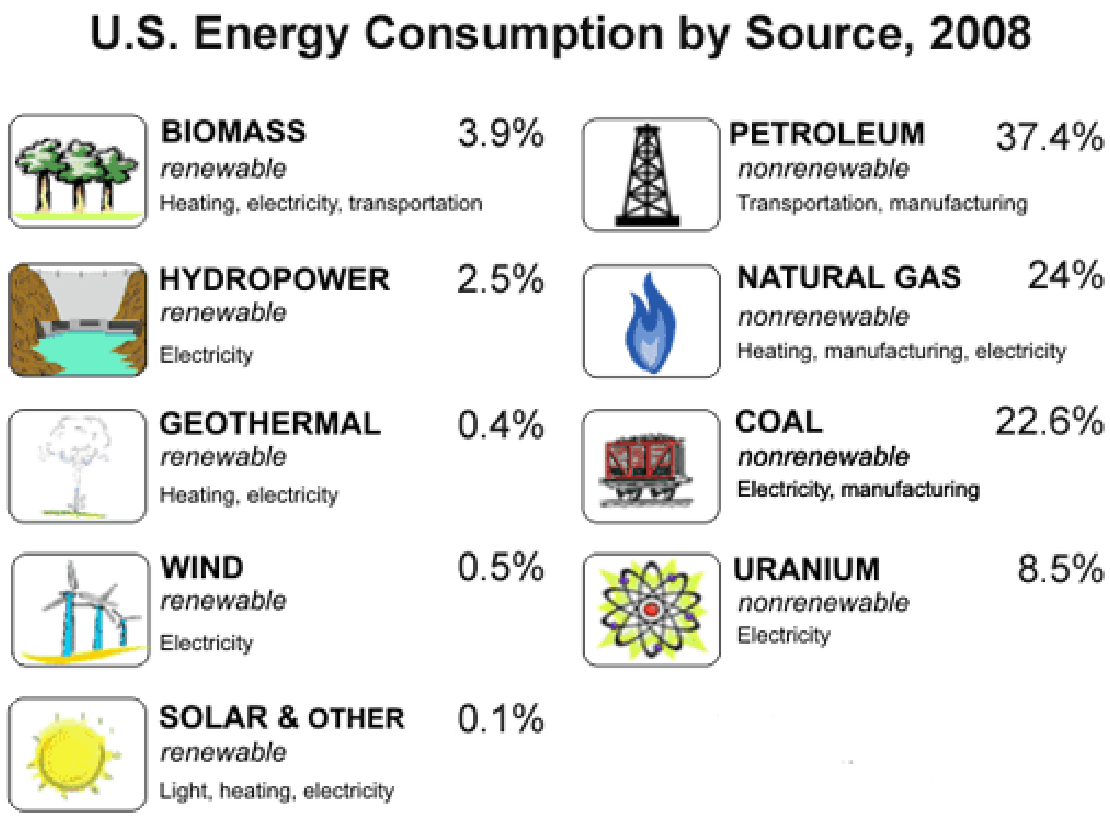
Students will complete “Do Now” paper and data record paper
Assessment
Student will report out results of their wind tunnel activity

LESSON 5 - WIND ENERGY – ADVANTAGES AND DISADVANTAGES
Objective: Students will discuss and do research on the advantages and disadvantages of wind energy as a potential major energy resource. They will list their findings and present them to the class. They will complete the Evaluation Survey.
Materials/Recourses
Computer Lab
Evaluation Survey
Student Grouping
Individual
Teaching Strategies/Demonstrations/Activities/Explanations
Students will use the school computer center to research wind energy by using search engines or websites given: www.eia.doe.dov/kids/ www.need.org www.renewableenergy.com They will complete the student evaluation survey
Closure
Student oral reports
Assessment
Percentage of correct answers on survey

DO NOW

DATE:	
Topic:	Objective:
Activity:	What did I do?

What did I observe?	What do I think it means?



Source: EIA, Annual Energy Review (2008)

http://tonto.eia.doe.gov/kids/energy.cfm?page=about_forms_of_energy-sources

Name ________________________ **Date** _________________________

Survey

1. The ability to do work is called....
   a. energy b. electricity c. a job

2. Wind is...
   a. moving clouds b. moving trees c. moving air

3. The energy in wind comes from the...
   a. earth b. sun c. ocean

4. Wind is made by the uneven heating of the...
   a. earth's surface b. sun c. ocean

5. Wind moves best...
   a. in the forest b. over flat land c. in the city

6. A tool that measures the speed of the wind is a(n)...
   a. anemometer b. thermometer c. weather vane

7. A tool that shows the direction the wind is blowing is a(n)...
   a. anemometer b. thermometer c. weather vane

8. A wind turbine uses wind energy to make...
   a. electricity b. heat c. motion

9. What part of a wind turbine captures the wind?
   a. tower b. gear box c. blades

10. Give two reasons why wind is a good energy resource.

____

____

Works Cited

Scrosati, B. ""Batteries"." Workshop on "Physics for Renewable Energy". The Abdus Salam International Centre for Theoretical Physics ICTP. University of Rome 'La Sapienza', Rome. 17 Oct. 2005. Lecture.

Goetzberger, Adolf. ""Physics of Renewable Energy"." Workshop on Physics for Renewable Energy". Fraunhofer Instut for Solar Energy Systems. Institute for Solar Energy, Miramare-Trieste, Italy. 17 Oct. 2005. Lecture.

Council Staff. "Tomorrow's Energy Today." *U.S. Fuel Cell Council* 1 (2010): 10,11. Print.

"DOE - Fossil Energy: An Introduction to Oil Well Technology." *DOE - Fossil Energy: Office of Fossil Energy Home Page*. N.p., n.d. Web. 26 May 2010. <http://fossil.energy.gov/education/energylessons/oil/index.html>.

"DOE - Fossil Energy: Introduction to Coal Technology." *DOE - Fossil Energy: Office of Fossil Energy Home Page*. N.p., n.d. Web. 26 May 2010. <http://www.fossil.energy.gov/education/energylessons/coal/index.html>.

Energy Information Administration - EIA - Official Energy Statistics from the U.S. Government. N.p., n.d. Web. 26 May 2010. <http://tonto.eia.doe.gov/kids/energy/cfm?page=nuclear_home-basic>.

"Fossil Fuels." *EIA*. N.p., n.d. Web. 20 Apr. 2010. <www.fossil.energy.gov.education/energylesson/coal/index/html>.

"Global Warming." *Climate*. National Climate Data Center, n.d. Web. 13 Apr. 2010. <www.ncdc.noaa.gov/oa/climate/globalwarming.html>.

"Global Warming." The Globe Program N.p., n.d. Web. 13 Apr. 2010. <www.globe.gov.fsl/htlm/templ.cgl?elemGLOBE>.

Investigating Renewable Energy. Rowley.MA. Didax Educational Recourses, 2006.

"KidWind | Wind Energy Education Turbines Lesson Plans." *KidWind | Wind Energy Education Turbines Lesson Plans*. N.p., n.d. Web. 25 May 2010. <http://www.kidwind.org>.

Lottero-Perdue, Pamela S., Sarah Lovelidge, and Erin Bowling. "Engineering For All." *Science&Children* 1 Mar. 2010: 24-27. Print.

"NREL: Photographic Information exchange Home Page." *National Renewable Energy Laboratory (NREL) Home Page*. N.p., n.d. Web. 25 May 2010. <http://www.nrel.gov/data/pix/>.

"National Energy Education Development Project." *National Energy Education Development Project*. N.p., n.d. Web. 25 May 2010. <http://need.org>.

"Natural Gas." *DOA Fossil Energy*. N.p., n.d. Web. 20 Apr. 2010. <www.fossil.energy.gov/education/energylessons/gas/index/html>.

Pacella, Rena Marie. "The Next-Gen Wind Turbine." *Popular Science* 1 Apr. 2010: 42,43. Print.

"USFCC." *USFCC*. N.p., n.d. Web. 25 May 2010. <http://www.usfcc.com>.

Yeager, Robert. "A View of the Importance of Six Domains for Teaching and Assessing

Science Learning." *Science&Children* 1 Apr. 2010: 3,4. Print.
Graham, Ian. *Energy Forever? Wind Power*. Austin, Texas: Raintree Steck-Vaughn,1999. Print.

Annotated Bibliography

Yeager Robert A View of the Importance of Six Domains for Teaching and Assessing Science Learning NSTA Reports March 2010 Former president of the National Science Teaching Association writes about the focus of future science teaching

EIA, Annual Energy Review (2008) Energy Kids Forms of Energy Sources of Energy charts U.S. energy consumption by source for 2008

Goetzberger, "Physics of Renewable Energy" International Center for Theoretical Physics (ICTP) TIPS course lecture handout, useful teacher background information with pictures charts and formulas in an easy to read format.

U.S. FUEL CELL COUNCIL Industry Overview 2010 "Tomorrow's Energy Today" Overview of fuel cell benefits and applications
www.usfcc.com

"Batteries" Workshop on "Physics for Renewable Energy" October 17 – 29, 2005 B. Scrosati University of Rome 'La Sapienza' Italy The Abdus Salam International Centre for Theoretical Physics ICTP TIPS course lecture handout, extremely thorough, highly technical article, with many charts, graphs pictures, and scientific formulas

Renewable Energy Sources for the Vertical Farm Claudia Cujar Carolyn Hettrich Hannah Kellogg Gilma Mantilla TIPS course lecture handout, great for tables graphs charts and pictures on all renewable energy sources

Popular Science April 2010 "The Next – Gen wind Turbine" by Rena Marie Pacella Illustrations by Nick Kalaterakis p.42-43 Short article about giant wind turbine being developed

The Abdus Salam International Centre for Theoretical Physics Workshop "Physics for Renewable Energy" October 17 – 29 2005 "Wind Energy" L. Pirozzi ENEA-Centro Recerca della Casaccia S.Maria di Galeria, Rome Italy TIPS course lecture handout highly technical comprehensive with many tables graphs and charts

Investigating Renewable Energy Activities for the renewable energy kit. Didax Educational Resource Copyright 2006 Didax Inc. Rowling, A 1969

www.globe.gov/fsl/html//temp.cgl?elemGLOBE Locates and graphs global data to learn about concepts of earth system science

Annotated Biography for Teachers

http://www.kidwind.org Great source for wind energy curriculum, materials, and resources

http:tonto.eia.doe.gov/energyexplained/index.cfm?=electricity_batteries Excellent site explains basics clearly, simply

www.need.org National Education Energy Development Promotes energy awareness through education and networks of students, educators, business, government and communities leaders excellent comprehensive site for complete lessons on most energy topics

http://www.ncde.noaa.gov/oa/climate/globalwarming.html world's largest archive of climate data

http:/www.ncdn.noaa.gov/oa/climate/globalwarming.html Global Warming Frequently Asked Questions This 14 page report is a brief synopsis of the 2007 Intergovernmental Panel on Climate Change (IPCC) has many useful tables graphs and charts to help answer 11 questions concerning the topic of climate change.

www.fossil.energy.gov.education/energylesson/coal/index.html Excellent site for all things related to fossil fuels. Lessons for classroom use with tables graphs charts and pictures.

Science & Children March 2010 volume 47 Number 7 "Engineering for All" Pamela S. Lottero -Perdue, Sarah Lovelidge, and Erin Bowling Windmill design lessons, EiE design process

Annotated Biography for Students

http://tonto.eia.doe.gov.energyexplained/index.cfm?page=hydropower_home good student website for background information

http://www.sciam.com/article.cfm?id=tidal-wave-renewable-energy shows pictures of tidal turbines

http://tonto.eia.doe.gov./kids/energy.cff?page=wind_home-basic wind basics and background information on wind energy

Peterson, Christine. *Wind Energy*. Waterbury Conn.: Scholastic Inc., 2004. Print. Great photographs, illustrations and history of wind energy, good elementary or middle school resource

Rickard, Graham. *Wind Energy*. Milwaukee, Wisconsin: Gareth Stevens Children's Books, 1991. Print. Good background information on history of wind energy, good for elementary or middle school students

Resources

Video
Bill Nye The Science Guy "Wind" Excellent fast paced video with plentyof information on wind and how it can do work. Great for student and teacher background information.

APPENDICES
Pennsylvania State Standard: 3.2.5: Inquiry and Design
PA Standard Statement: 3.2.5. B Describe objects in the world using the five senses.
Content Performance Descriptors: 3.2.5.B.2: Design controlled experiments, recognize variables, and manipulate variables.
Science, Grade 5
PA Standard Statement: 3.2.5.C.: Recognize and use elements of scientific inquiry to solve problems.
Content Performance Descriptors: 3.2.5.C.2: Design an investigation with limited variables to answer a question.

Grade Five PA Science Standards
3.1.7: Unifying Themes
- A: Explain the parts of a simple system and their relationship to each other.
- B: describe the use of models as an application of scientific or technological concepts.
- C: Identify patterns as repeated processes of reoccurring elements in science and technology.
- E: Identify change as a variable in describing natural and physical systems.

3.2.7: Inquiry and Design
- A. Explain and apply scientific and technological knowledge.
- B. Apply process knowledge to make and interpret observations.
- C. Identify and use the elements of scientific inquiry to solve problems.

3.4.7: Physical science, Chemistry and Physics
- B: Relate energy sources and transfers to heat and temperature.

3.7.7: technological Devises
Use appropriate instruments and apparatus to study materials.

3.8.7: Science Technology and Human Endeavors
B. Explain how human ingenuity and technological resources satisfy specific human needs and improve quality of life.