Energy and The Environment

By
Trudi Busha-Smith
Arsenal Middle School

What is energy?

Energy is not an easy word to define, you cannot see it, hold it, or make it. Everyone knows what energy is, but has difficulty explaining it. People often refer to their own level of energy or how they use energy. Simply put energy is the ability to do work.

All plants and animals harness energy from the sun, to help them grow and survive. Man has developed ways to harness energy to do work for him. This unit will explain how this has impacted the Earth.

This unit is written for the seventh grade students at Arsenal Middle School. Arsenal is an urban school in Pittsburgh, PA. We currently are a pilot school for the High Performance Schools. It is the goal of this program to teach children that decisions they make affect the Earth. Currently the program focuses on chemicals used in the building, this unit will focus on choices made in energy consumption affecting the planet. Now that Pennsylvanians can choose their energy supplier this will empower students to make Knowledgeable choices when the time comes. Seventh grade students will explore the transportation crisis, how do we travel in a vehicle in an economic and friendly manner.

Arsenal has a very active S.E.C.T.E.M. (Students, Employees, Community Teamed for Energy Management) Committee. Student driven, the program empowers students to practice energy conservation at school. Students make signs and posters reminding staff and students to conserve energy. The students run a recycling program, and present a recycled fashion show for the sixth graders. Currently the sixth grade students are taught about the energy sources available to man. It is the goal of this unit to review each energy source and provide a hands on activity to demonstrate what the energy source really is. Students will then need to draw conclusions on the best energy source currently available to mankind. Students will make their decisions based on supply, economics, and environmental impact. Students will then explore vehicles, since they consume the most oil in the United States. Students will identify the current energy sources used to fuel a car. Students working in groups, will calculate the cost of running a particular vehicle for five years, using a certain fuel (to be assigned by the teacher.) Students will share the results and identify the best source available to fuel a car.

We will begin with the renewable energy sources, or alternative energy sources. The first we will examine is solar energy. Without solar energy no other energy would exist, it causes the wind to blow, the water currents, and photosynthesis of plants.

Man has used the sun, for it's radiant energy since the beginning of time. We even change our schedules twice a year to take advantage of the sun's energy (daylight savings). We have advanced to the point where we can harness the sun to run calculators, cars, and houses.

We currently have several ways of collecting energy from the sun. The first method uses photovoltaic cells(P.V.cells), also known as solar cells. These cells use semiconductor material to directly convert sunlight into electricity. The photons, particles that make up light knock electrons loose in the semiconductor, creating an electrical charge. These systems run calculators, street lights, highway signs, and some houses. P.V. cells used to run calculators and watches are only1.2 centimeters in diameter. To power a larger system, cells are ten centimeters in diameter. P.V. cells are wired together to form a module. One module can produce enough energy to light a sixty watt bulb. P.V. modules are wired together to produce an array. An array can produce enough electricity to meet the needs of an average house.

People can heat and cool their homes using flat plate solar collectors, these collectors are large flat boxes with two layers of glass, covering a layer of dark colored metal, or aluminum painted black, and tubing filled with water, or air. This system works, by using sunlight to heat the air/water inside, the tubing inside the solar collector. The air/water is pumped directly into the house, or stored for use at night, or on cloudy days. Flat plate solar collectors are either active, using pumps, or fans to move the water through the home, or passive. In a passive system design features are used, such as natural day lighting, using sunspaces as solar collectors, and building heat retaining walls. Back-up systems are needed to account for cloudy days and nights. These solar heating systems are expensive to install, but they can lower electric bills, and reduce the amount of fossil fuels used.

We have also developed three methods of "concentrating solar power". These systems use the heat generated by the sun. In each system sunlight is focused on to a receiver. The sunlight is converted to heat, that is transported to a generator that converts it to electricity.

The first "concentrating" system is the trough system. Solar collectors are shaped like a trough. Running through the trough's focal point is a tube filled with a liquid. The fluid is heated, and carried to a generator. This system is used in the World's largest solar energy plant, located in California. It meets the energy needs of 350,000 people annually.

A dish system, using parabolic mirrors to focus the energy on a receiver mounted above the dish, is the second "Concentrating" system. These dishes produce anywhere from 5 to 50 kilowatts of electricity. These dishes can be used independently, or linked together to create more power.

The final system is a central receiving. Individual mirrors, called heliostats, reflect solar energy onto a receiver located atop a tall tower. The world's largest central receiving plant is also located in California.

The United States currently uses more than seventy-one trillion BTU's of solar energy annually. We estimate that one million BTU's of solar energy generates as much electricity as ninety pounds of coal, or eight gallons of gasoline.

There are advantages to using solar energy. Solar energy is clean, renewable, domestic energy. Power systems can be constructed at any size, to meet energy needs, and easily changed to meet changing needs. However, solar energy is very intermittent, and back up systems are needed. To use solar systems effectively, you must live in an area with intense sunlight. Solar heating/ cooling systems are currently more expensive than conventional systems.

I have chosen the following activities to help the students understand the current methods we us to harness the sun's energy. These are method that the students can easily make, or perform, and are inexpensive to do.

Activity #1

Objective: Identify the materials that best absorb the sun's energy (This activity would be done prior to a discussion of solar energy, to start students thinking about the results) Students will work in groups of four students. This activity will help students to meet Science Content Standard of collecting and analyzing data. Materials are listed for each group.

Materials:

4 Foam cups
4 thermometers
water
sand
food coloring
graph paper

Procedure:

1. Fill two of the cups _ full of water.
2. Add food coloring to one of the water cups.
3. Fill the third cup with _ with sand.
4. Leave the fourth cup empty.
5. Set the cups in the sun.
6. Record the temperature every four minutes.
7. Graph the results.

Conclusion:

Students should identify which substance absorbed the most heat. Students should draw inferences from their graphs, and compare their graphs to their classmates.

Activity #2

The students will make several solar cookers.
Students working in groups will construct a solar cooker to make Smores. Each group will make one of three solar cooker. Students will measure the time it takes to cook their smore in their cooker. Students will share their results with the class. The class will analyze the data and determine which model was the most efficient. This activity also meets content standard six of the science standards.

To simulate a dish system
Materials:

Rounded bowl (wooden salad bowls work well)
Aluminum foil
Double sided tape
Graham crackers
Chocolate
Marshmallow

Procedure:

1. Students will line the bowl with aluminum foil. Shiny side up, using the tape to secure the foil. Students will want to make the foil as smooth as possible.
2. Place the graham cracker in the bottom of the bowl.
3. Place the chocolate bar on top of the cracker
4. Place the marshmallow on top of the chocolate.
5. Place the bowl in the sun and start timing the experiment
6. Observe the experiment until the chocolate, and marshmallow have melted. Stop the timer. Record the data.
7. Place a graham cracker on top of your experiment remove from the solar cooker and eat.
8. Repeat the process three times to collect sufficient data (and allow each member of the group to eat a smore)

Solar cooker #2
A modified trough system
Materials:

Piece of oak tag
Aluminum foil
Double sided tape
String
Materials for s'mores (chocolate bar, 2 graham crackers, marshmallow)

Procedure:

1. Pace the aluminum foil shiny side up on the oak tag. Use double sided tape to secure it.
2. Bend the oak tag into a semicircle. Tie a string around the semicircle to hold it in place.
3. Place the cooker in the sun.
4. Place the ingredients for smores in the cooker (same directions from last experiment)

Wind Power

Wind Power is an indirect form of solar energy. Wind is created when temperature differences occur on the surface of the Earth.

Wind was one of the earliest forms of energy to be harnessed. As early as 3500 B.C. wind was used to move boats with clothe sails across water. It was also used to grind grain and pump water.

We now use wind turbines, with two or three blades, instead of the many bladed windmill of days gone by. The blades of today are much longer some are eighty –two feet long. The blades are attached to a head. Inside the head is a generator. The heads can rotate to keep the blades pointed into the wind. Large groups of wind turbines are called wind farms or wind plants.

Wind is classified into seven classes. Class seven winds are the strongest and class two winds are considered mild breezes. Winds need to be classified as class four or stronger to produce electricity.

The United States currently produces three billion kilowatt-hours of electricity per year. This is enough energy to meet the residential needs of one million people for one year. Ninety percent of the wind energy in the U.S., is produced at three wind plants in California (Altamont Pass, Tehachapi, and Palm Springs).

The advantages of wind energy are that it is a clean renewable energy source. It can produce energy both during the day and at night.

The disadvantages of wind energy are that turbines need strong winds, so they have limited areas where they can be used. The wind does not blow in predictable amounts a back-up source needs to be used also.

I have chosen for the students to make several different devices that move in the wind, so the students can infer and create a design that will cause the wind to spin it. This activity relates to the Science Standard number six, students will experiment, then use the results to help create a new experiment.

Hydroelectric Power

Using water to turn machines to grind corn has been used since 100 B.C. .In the twentieth century water supplies twenty-four percent of the world's electricity.

Hydropower converts the energy in flowing water into electricity. A hydropower plant includes: a dam; to create a "head" (The height of the water from the turbines in a power plant to the water surface.), penstocks (pipes) carry water from the reservoir to the turbines inside a power house. The water turns the turbines, which drive generators that produce electricity. The electricity is transmitted to a substation, where transformers increase the voltage.

The first hydro-electrical power plant was built in 1882, in Appleton, Wisconsin. It provided enough electricity for one house and two paper mills. The United States is the world's leading hydropower producer. Hydropower supplies nine percent of the electricity for the United States. Forty-nine percent of the renewable energy used in the U.S. is hydropower.

Globally hydropower is producing the amount of electricity it would take 3.6 billion gallons of oil to produce annually. The largest hydropower plant is in Brazil.

The advantages of hydro electrical plants are: it is a clean, renewable, domestically available option.
The disadvantage of hydro power is environmental. Damming rivers has an impact on the surround animal habitat. It also ruins scenic locations.

The activity for hydropower is for students to construct a water wheel. Student's may construct the wheel out of materials they have at home. The students will bring the wheel into school and test the efficiency of their wheel. The students will vote on the best water wheel.

Geothermal Energy

The word geothermal means earth (geo) and heat(thermal). There are five forms of geothermal heating, we currently only use two. Hydrothermal energy is created below the Earth's crust. Water flows through permeable rock that is heated, creating steam, or hot water, that travels to the surface. The second energy that we currently use is Earth's energy. This energy found in shallow ground, and is used directly to cool ,or heat our homes. The other three forms of energy need more technological advances before they can be utilized, they are hot dry rock, magma, geopressured brines.

The world's largest geothermal plant is located in Northern California. The Geysers Power Plant produces as much power annually, as two large coal or nuclear power plants.

The advantages of geothermal energy are they are reliable, environmentally friendly, and domestic energy.

The disadvantages are that supplies can be depleted if not given time to replenish. Geothermal waters contain trace minerals that are corrosive and polluting.

Geothermal Activity

The purpose of this activity, is to demonstrate to the students how geothermal energy works (blows up the balloon). This activity will help students with the communication standard, they will record their observations.

Materials:

Plastic Milk Jug
Balloon
Bucket of Hot Water
Bucket of Ice Water

Procedure:

1. Put the empty milk jug and balloon in the refrigerator for one hour.
2. Squeeze all of the air out of the balloon and slip it over the neck of the jug.
3. Put the jug in the bucket of hot water.
4. Once you observe no more change, place the jug in the bucket of ice water.
5. Record observations.

Biomass

Biomass produces energy by burning substances. Currently the substances being burned are garbage and plant material. There are three ways biomass materials are used. The first is to burn materials directly to produce heat and electricity. The second is to turn the biomass into a liquid fuel, such as ethanol and methanol. Finally biomass can be turned into a gas, such as methane.

The importance of a liquid fuel, is that it could be used for meeting our transportation needs. One third of our energy, is currently used for transportation.

The advantages of biomass are that it is cleaner than burning fossil fuels. It is renewable, and reduces waste in landfills.

The disadvantages are it is more expensive to produce than fossil fuels, and transportation would need to be refitted to burn the new liquid fuel.

The activity chosen for biomass will allow students to see how biomass produces a fuel.

Nuclear energy

Before we can talk about nuclear energy, students must first understand the atom. An atom is mostly made up of space, but is also made up with tiny particles. The nucleus is the center of the atom, it is made up of protons, that carry a positive charge, and neutrons that carry no charge. Protons and neutrons have the same amount of mass.

The total of neutrons and protons is referred to as the mass number. A chemist identifies an atom by the number of protons in the nucleus. This is referred to as the atomic number. Almost all of the mass is in the nucleus of the atom. Surrounding the nucleus is a cloud of electrons. An electron carries a negative charge. It has very little mass, in fact it takes two thousand electrons to equal the mass of one proton. Electrons arrange themselves in shells around the nucleus.

Chemists refer to atoms by their atomic numbers because isotopes exist in all elements. An isotope is an element that has different numbers of neutrons in the nucleus. The atomic weight of an element is average weight of a mixture of the elements isotopes. For example Hydrogen. Normal hydrogen atoms have no neutrons, some atoms have one neutron. The weight of a hydrogen atom and its isotope are 1.0078252 and 2.0141022. They average to hydrogen an atomic weight of 1.00797.

A nucleus is said to be stable when the protons and nucleus are in ratio to each other. The nucleus shows no tendency to change, Atoms heavier than Bismuth(83) are said to be unstable and naturally radioactive. Elements with an atomic number higher then 92 are not found in nature, but are made by scientist.

What is Nuclear Energy?

Nuclear fission was first achieved in 1939. During nuclear fission, the nucleus of a uranium isotope is split into two smaller nuclei and neutrons. One pound of uranium will release the energy equal to burning 3,000 tons of coal.

Nuclear fusion is how the sun produces energy. It is the process of joining two lighter atoms together, causing a greater mass to energy ratio than with fission. We currently cannot produce energy economically with fusion.

The advantages of nuclear energy are: It produces fewer pollutants into the environment than fossil fuels.

The disadvantage of nuclear energy is the radioactivity and nuclear waste it produces.. Radioactive materials can penetrate the human body. Repeated exposures to radioactive particles can cause cataracts, some forms of cancer, and damage to the reproductive cells. Nuclear waste can not be easily disposed, it must be stored and watched for hundreds of years to come.

The first commercial nuclear power plant was built in 1957, in Shippingport, PA. On March 28,1979 an accident at Three Mile Island, near Harrisburg, PA scared the United States of nuclear energy. Reactor number 2 was operating at almost full capacity, it automatically shut down due to a faulty feed water pump. Pressure and steam built up in the reactor forcing a release valve to open. When the pressure and temperature returned to normal the valve should have closed, but did not. For over two hours the

reactor leaked water causing the fuel core to be exposed, without coolant. Temperatures in the reactor rose and the uranium fuel cores began to melt. When the valve did close, operators became aware of the missing water, and reintroduced water into the system. This caused some fuel rods to shatter. The water did cool the system down and prevented a complete melt down. Most of the radioactivity was contained in the plant. Krypton 85 gas accumulated in the building and a million gallons of radioactive water was in the basement of the plant.

The Chernobyl accident was not the same as Three Mile Island, but an experiment that got out of hand.

During a scheduled shut down of the reactors, operators wanted to experiment what would happen if the plant had a minor accident. The experiment was to bring the power down to 25% of the maximum out put. They attempted to do this by inserting the control rods into the reactors. They dropped the production to 1% of the maximum. Operators became nervous and bypassed safety systems. They withdrew the control rods causing a chain reaction. Pressure, steam and temperatures rose causing an explosion. The roof of the containment building collapsed. The radiation was released into the air. Dozens of people died from radiation exposure.

Although nuclear energy does have its advantages, like producing tremendous amounts of energy, with little direct pollution to the environment. It is hard to rely on an energy that causes radiation and wastes that must be stored and watched for generations to come.

The activity I choose will help students to understand what nuclear fission is, the splitting of an atom.

Materials:

- glass
- water
- rubbing alcohol
- cooking oil
- spoon
- plastic knife
- paper towels
- teaspoon

Procedures:

1. Put 100 ml of rubbing alcohol into a glass container
2. Add 50 ml of water
3. Stir the mixture
4. Add one teaspoon of oil to the mixture. Carefully tip the spoon below the surface so an oil drop is released. It should float in the middle of the container
5. If the oil drop floats to the surface add more alcohol

6. If the oil drop sinks add more water to the mixture.
7. Use the knife to separate the oil drop in two.
8. Continue trying to "split atoms" until you can no longer split them
9. Record results on lab sheet

Activity two for Nuclear energy will help students understand radio active decay.

Materials:

100 pennies for each group
1 shoe box with lid
graph paper

Procedure:

1. Put the pennies in the shoe box
2. Put the lid on the shoebox
3. Shake the shoe box for two minutes
4. Open the lid
5. Remove all of the pennies that are facing head side up. This represents the atoms that have decayed.
6. Record the number on lab sheet
7. Repeat steps 2-6 until no pennies remain
8. Graph the results

Fossil fuels are made from decomposed plants and animals that were compressed under great pressure, between 350 to 50 million years ago. We have three types of fossil fuels coal, oil and natural gas.

We will explore coal first. Coal was formed from the remains of ferns, trees, and grasses. These remains formed layers under the water of the swamps. The partially decayed plants formed peat. Peat is a soft brown substance, that is thirty percent carbon. It is the first stage of coal. As time went on more layers were formed on top of the peat, compacting it with heat and pressure. Slowly the peat was transformed into lignite, or brown coal. Lignite is forty percent carbon, it contains a lot of moisture. We primarily use lignite for producing electricity. Millions of years later, with more heat and pressure, the coal is transformed into Bituminous coal. Bituminous coal is sixty six percent carbon, with very little moisture. It is used for making coke in the steel industry, and generating electricity. The hardest coal is anthracite. It is over ninety percent carbon. It has a very high heat value, and burns very slowly. It makes a good home heating fuel.

There are two ways to extract coal. The first method is strip mining. This method is safe and economical. It is used when coal is close to the surface. First the coal is uncovered, by large machines. Rock is put in already mined areas. The topsoil is set aside to be replaced when mining is through. The coal is broken into manageable pieces with the help of explosives. The coal is removed. The area is then covered with the topsoil and reseeded with grass.

The second method is underground mining. It is used to extract coal that is deep within the earth. Coal is reached by making two holes in the coal bed, so air can circulate. Air in the mine can be dangerous if gases are allowed to accumulate. The coal can be mined in several ways;. with the use of explosives, continuous mining, with large machines, and the long wall method. The long wall method uses a machine that cuts coal along a wall that is anywhere from 300 to 700 feet long.

The advantages to using coal are that it is plentiful and economical in the United States.

The disadvantages of using coal are that by burning coal many by-products are produced. Carbon dioxide, carbon monoxide, sulfuric oxide and nitrogen dioxide are gases produced. Iron sulfide, found in coal, is very acidic and contaminates water supplies. Sludge, a by product of coal needs to be dealt with as well.

Oil, another nonrenewable fossil fuel, supplies us with forty-five percent of our energy. Oil, also known as petroleum means rock (petro) and oil (lium).

Millions of years ago, plants and animals died, and over time mud and sand changed to stone. Increasing heat and pressure turned the dead plants and animals into petroleum. In the porous rock layers reservoirs of oil were formed.

Oil has been use for many years. Ancient Greeks used oil, to throw on the sea, and light on fire enemy fleets. Pitch, a thickened form of oil was used by American Indians to waterproof canoes. In 1859 drilling for oil began in Titusville, PA. Colonel Edwin Drake drilled 69 feet and struck oil. Anthony Tucus, a mining engineer, believed oil could be found in salt dome formations. In 1902 around Beaumont Texas he struck oil proving his theory. From 1901 to 1920 America had an increased demand for oil. The invention of the mass-produced automobiles and World War I are among the reasons for the increased demand. From 1921 to 1940, scientists developed more re-fining techniques so that more gasoline and related products could be produced by one barrel of oil. Today we make many products from oil, such as plastics, detergents, paints, varnish, films, medicines, and synthetic products like rubber and fibers. An average barrel of oil produces 18 gallons of gasoline, 10 gallons of kerosene, 5 gallons of residential fuel, 3 gallons of jet fuel 2 gallons of lubricating oil, asphalt and wax.

How do we get oil? First we must find a supply. Scientist use land formation clues such as the dome formations. They also use sound waves, radar and magnetic readings. Scientist then bore holes to study core samples. Construction crews must clear the site, build roads and assemble a drilling rig. During drilling a special mud is prepared to keep the drill bit cool. Operators must have a blow out preventer, to shut down the pipe in case of an emergency. Currently only one fourth of the oil is recaptured by natural flow and pumping. Companies use water flooding techniques to get more oil out of the wells. The Heat method is to inject steam, causing the oil to thin, making it easier to flow. In water flooding water is pumped into the edges of the well, forcing the oil to

the center. We still can not recover all of the oil in a reservoir, under the current circumstances.

The biggest advantage of oil is the ease of it's refining. It is used for heating, cooling, transportation, and medicines.

The biggest disadvantage of oil is that it produces gases that are bad for the environment when burned. During transportation there can be accidents causing damage to the land and oceans. Current technology can not recover all of the oil, and newer methods are not cost effective.

Natural gasses are often found by petroleum. The layers of the rock that trap the gas and oil are called cap rocks. They trap the gas underground. When the gas and oil reach the cap rock, they separate. The gas collected contains salt water that must be removed. Gas-well gas, must be gathered and treated in the field, compressed and sent to a central processing unit. There it will be separated into natural gas and natural gas liquids.

The students will now do the final activity, a worksheet designed to help them identify how much money it would cost to run an automobile using an alternative fuel. This activity will help the students meet the math standards, the communication standard, and the science standard.

Vocabulary for energy

1. Biomass - The process of changing farm waste, plant material and other things into energy by burning it, changing it in to a gas, or converting it in to a liquid fuel.

2. Energy crops - Crops grown specifically for their fuel value, such as corn, sugarcane, poplar trees and switch grass

3. Fossil Fuels - Energy sources formed by the decay of plants and animals over millions of years: coal, oil, and natural gas are fossil fuels

4. Geothermal energy – Using the heat of the earth to produce energy

5. Hydropower - Using the energy in flowing water to make electricity

6. Nonrenewable fuels - Fuels that can not be easily made. We can use up nonrenewable fuels. Oil, coal, and natural gas are nonrenewable fuels

7. Nuclear energy - Energy produced from changes in the nuclei

8. Parabolic collector - A U-shaped mirrored trough that focuses sunlight onto a tube running down the center of the trough.

9. Photovoltaic energy - A type of solar energy that converts sunshine into electricity

10. Photovoltaic cell - Also known as a solar cell: A means of converting sunlight into energy

11. Passive solar heater - A solar water-heating or space heating system that moves heated air or water without using pumps or fans.

12. Passive solar home - A house that uses a room or another part of the building as a solar collector

13. Renewable energy - Types of energy that are "renewed" as we use them; solar, wind, and geothermal are renewable forms of energy.

14. Solar collector - Boxes, frames, or rooms that trap the sun's rays to produce heat

15. Solar energy – Energy from the sun.

16. Sunspace - A room that faces south, or a small structure attached to the south side of a house.

17. Thermo siphoning - An event where heated water in a solar collector becomes lighter and rises to the top and cooler water becomes heavier and sinks to the bottom.

18. Wind power - Using the wind to produce electricity by turning blades of a wind turbine

19. Wind power plant - A group of wind turbines interconnected to a common utility system.

The purpose of this unit

This unit is being created for the seventh grade at Arsenal Middle School. Arsenal has a very active S.E.C.T.E.M. (student, employee, community teamed for energy management) program. This lesson will build upon the sixth grade curriculum, and seventh grade curriculum already in place at Arsenal.

Arsenal is also a pilot school for the high performance school. It is our goal at Arsenal to teach students to make informed decision that will affect the world. This unit will present information to students and help them make informed decisions about their energy uses.

Bibliography

How Science Works, Judith Hann, Readers Digest, New York, 1991

Science Encyclopedia, Lawrence Lowery, King Fisher, U.S. 1993

Physical Science Activities for Grades 2-8, Marvin Tolman and James O. Morton, Parker Publishing Company, West Nyack, New York, 1986

Science Is… , Susan V. Bosak, Scholastic Canada, Ontario Canada, 1991

Hands On Science Experiments, Deborah Crotts, Frank Schaffer Publications, Torrance California, 1993

Clean Air Challenge, John Lord, Enterprise for Education, Inc., Santa Monica, 1998

Real-Life Science Series Classroom Experiments, Pam Beeman and Mary Jo Bollinger, Frank Schaffer Publications, Torrance California, 1996

Principals of Science Book Two, Charles E. Merrill Publishing Co., Columbus Ohio, 1979

Coal : Energy for Home and Community; Carol Adams, Rosemary Sabat, Susan Zutter, Dennis Finseth, Stephanie Noeti; Federal Energy Technology Center, 1991

Energy in American History; The Energy Source Education Council, 1984

Power Switch; The Energy Source Education Council,1982

Coal and Coke in Pennsylvania; Carmen DiCiccio; Commonwealth of Pennsylvania, Pennsylvania Historical and Museum Commission, Harrisburg, 1996

Http://www.nrel.gov/lab/pao/wind_energyu.html
http://www.nrel.gov/lab/pao/hydroelectric.html
Http://www.energy.ca.gov/education/resources/research.html/resources.html
Http://www.ase.org/educators/lessons/fossil.html