Energy: Exploring Alternative Forms

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"Real Science for students is when they are thinking scientifically"
-Richard Filson

INTRODUCTION

As I thought about this topic, I wondered how teaching it would be beneficial to my students. If I am to create a lesson for students, I myself must become familiar with its importance. I have an obligation to the next generation of scientists to show them that nonrenewable energy is a dying breed, and there must be a way to use and further understand alternative renewable forms of energy. In the study of science, there is always going to be research, data, theories and wonderful new discoveries. I feel that my interest about energy will help me design an adequate unit full of intrigue and discovery. The students should also understand after the study that we must include the use of alternative forms along with nonrenewable forms to make for a better balance of the world's energy use.

It is the purpose of this unit to acquaint the students with nonrenewable energy sources: coal, nuclear, oil, and gas. The students will also be told that, except for nuclear power, these nonrenewable energy sources are called fossil fuels. What are fossil fuels? They are fuels formed in the ground from remains of dead plants and animals that are buried in rock layers all over the earth that is burned to supply heat. It takes millions of years to form fossil fuels. What is coal? Coal is a solid fossil fuel found in the earth formed from the remains of decaying plant matter subjected to intense heat and pressure. Coal is comprised mostly of carbon and trace amounts of water, sulfur and radioactive materials. Coal is burned to produce electricity and heat. What is nuclear energy? Nuclear energy is energy that comes from splitting atoms of radioactive materials, such as uranium, which leave behind radioactive waste: radioactive waste is material left over from making nuclear energy. Radioactive waste can harm people and the environment if it not stored safely. What is oil? Oil is a liquid fuel found deep in the earth. Gasoline and some plastics are made of oil. What is natural gas? Natural gas is a fossil fuel found deep in the earth. Natural gas is often found with oil, it occurs in the same places as crude oil near hot spots where high temperature and pressure breaks down hydrogen. Discussing how these forms of energy are obtained, their common uses, and the environmental impact of their exploration and extraction is important. By explaining what each form of nonrenewable energy is, the students will see how we the consumer can help to reduce or save on energy usage.

The environmental impact of burning fossil fuels on the earth can be alarming: Processing of natural gas releases highly toxic hydrogen sulfide into the air, if ignited when it is transported it can cause huge explosions. The methane in natural gas is considered a greenhouse gas. By extracting coal, humans working in these mines remove soil and rock from the terrain, the workers have been known to contract a disease called (black lung) from prolonged exposure to the coal dust particles. Coal burning releases carbon monoxide and other gases into the atmosphere, and it also accelerates global warming. Also the loss of habitats for animal when coal is strip mined is tremendous. The problem with nuclear energy is deciding what to do with the leftover radioactive materials. How do we maintain nuclear plants? These questions have yet to be fully answered. Nuclear energy emits less air pollutants and contributes less to global warming, but it can cause death in unfortunate nuclear accidents. The only related death to a nuclear accident has been Chernobyl, but the possibility of large scale damage is present. The radioactive waste must be stored, but no plan has yet been found to be scientifically and economically practical. Do you want radioactive materials in your backyard?

The students should understand:

a. 90% of the energy we use in this country comes from fossil fuels.
b. The United States uses about 17 million barrels of oil every day.
c. Petroleum accounts for nearly 40% of our country's energy.
d. Coal is used to produce almost 60% of our nation's electrical power, and accounts for 22% of our overall energy consumption.
e. Natural gas, a third form of fossil fuel, accounts for roughly 23% of the United States energy usage.
f. The U.S is home to 5% of the world's population, yet consumes 26% of the world's energy. (US Dept. of Energy)

So what do all these statistics mean? It means that 90% of the energy we use in this country comes from fossil fuels. Shortages may well occur due to instability in the Middle East which will hold about 90% of oil reserves by around 2020. The amount of oil produced in the United States has steadily decreased; more than 50% of the oil is imported (Dieoff.org). It has been proven that burning these resources significantly damages the environment. The emission of harmful gases produces a gaseous blanket covering the earth, and this layer traps heat irradiated from the earth's surface by the light from the sun. This trapping of heat is referred to as the greenhouse effect and is responsible for global warming.

There will be some catastrophic climate change if we continue to use fossil fuels which release emissions into the air. In order to reduce emissions a government or company needs to consider the value of investing in new or improved energy supply versus other forms of mitigation such as energy efficiency measures. Listed are some of the changes that will occur:

a. Higher than normal maximum temperatures, more hot days and heat waves over all land areas.

b. Increased minimum temperatures and less frost, increasing activity of pests and diseases in crops.
c. Intense rainfall events leading to more floods, landslides, soil erosion, risk of infectious disease epidemics.
d. Summer drying over continental land areas leading to damage to building foundations from ground shrinkage.
e. Increases in peak wind intensities, storm events and tropical cyclones leading to increased coastal erosion and damage to coastal ecosystems such as coral reefs.
f. Higher CO2 levels increasing plant growth, but constrained by water shortages in some regions.

   These occurrences will certainly be remembered for having considerable impact on the future of the planet. (Sims)

My students will begin with the history of the solar cell used to create an alternative form of energy, the research done to create alternative forms, why research has been halted and what the future generation can do to help restore interest. Students already know that the sun is the closest star to earth and is the primary source of all energy harvested on the planet. All forms of energy come directly from the sun: it brightens our days, warms our bodies and homes, helps vegetation to grow and is a constant part of everyday life. This one energy source, the sun, can someday become one of our greatest alternative forms of energy.

This unit will introduce the students to nonrenewable energy sources such as coal, nuclear, oil and natural gas so they will understand why they are a dying breed. Nonrenewable sources are the ones that do get used up. The students will compare nonrenewable sources to renewable sources: sun, wind, water, heat from within the Earth (called geothermal energy), and plant (biomass) waste products. These renewable sources are all naturally occurring elements, because they are renewed all the time and will never run out. With the study of alternative energy forms students will become aware of how much nonrenewable energy resources we have used and will continue to use until society comes up with effective ways to produce new forms of energy.

The unit will be divided into several sections covering the study of electricity: solar, hydroelectric (water and wind), and fossil fuel generated electricity. Next we will look at heat and how it is created using solar panels, fossil fuel (oil) and natural gas. Then we will look at cars fueled by solar power, hydrogen, gas, and ethanol. This will lead to the understanding of how these various forms of energy are stored. Within this section students will be given specific vocabulary words used throughout the unit: solar, biomass, fossil fuel, hydroelectric, magma, geysers, turbine , nonrenewable, greenhouse effect, extract, geothermal, and photovoltaic (PV). The words will each be discussed, and as a group we will come up with our own definitions and compare them to the standard definitions. The students will also be shown pictures or actual items seen everyday; the sun, food (fruit or vegetable), vegetable oil, wood, charcoal, motor oil, a pinwheel, a picture of lightning, a light bulb, a piece of discarded trash, a battery, and a cup of water.

I want my students to recognize and explain how these items are energy sources. Students will then log on to <www.need.org/infobooks.htm> to take a preassessment on the science of energy.

My students will discover the history of alternative forms of energy which began in 1953, the research done to create the solar cell which began with a single 2cm photovoltaic (PV) cell which generated 5 milliwatts of electricity, and why it has been halted and what the future generation can do to help restore interest. The scientist that invented the solar cell was not trying to solve the energy problem. They were originally trying to solve problems with the Bell telephone system, and explore alternative forms of free standing power. We will discuss how this invention leads to usage of energy. We will also discuss the reason these forms were researched and the impact they have or have not had on the environment. With the creation of the solar cell in 1953 there has continued to be improvement to this day. The research team of Daryl Chapin, Calvin Fuller and Gerald Pearson of Bell Labs were not planning to invent a solar cell, but they revolutionized what is now the PV industry.

The unit will include information on the various parts of the country that are having some success using alternative forms of energy. We will investigate some of the many designs created that have successfully been used to produce power in homes, power plants, buildings, cars and the use of magma – where water is heated below the earth's surface and used to produce electricity. We will address the benefits and safety issues that have been cited. We will also look at the state of Texas to see what our state is doing to use alternative energy sources. While looking at our state Texas, students will gather data from Houston's Green Mountain Energy which provides alternate forms of energy to areas in our city. Using The Infinite Power of Texas website <www.infinitepower.org> will also provide data necessary to perform the survey. This discovery process will help students answer the question, "Why do we need another form of energy?" How will this form of energy become better than what we already have? How will using alternative forms of energy help our environment? Is there a significant change in cost to the consumer? Will these forms help in saving our fossil fuel usage?

UNIT

The following questions will guide the students in their study of energy:
a. What is energy and where does energy come from?
b. How much nonrenewable energy does our society use and how much do we need?
c. What other sources of energy are available?
d. Is there environmental safety issues involved with renewable energy sources?
e. What impact will the loss or depletion of nonrenewable energy have on our society?
f. How can society enhance the usage of alternative forms of energy?

What is energy and where does it come from?

We cannot see, feel, touch or taste energy; In fact we cannot really define energy. It is an intangible yet it appears in many familiar but different forms that can be defined. Energy is the ability to do work. It can come in forms of heat and light. There are two types of energy: working energy and stored energy. Stored energy becomes working energy when we use it. You eat food for energy. Then your body stores the energy until you need it. When we work and play, your stored energy becomes working energy. We use energy everyday. We use energy to grow our food, warm and cool our home, make our electricity. It runs our cars and makes our products. Energy is a very important part of our lives; it is the sun, the wind, the water, wood and remains of plants and animals.

Ask any student where electricity comes from and they will probably say the power company. This is the expected answer, because students have no real concept of where the supply of energy comes from. All they know is that it is needed to run their televisions, computers, VCR's, appliances and not to mention lights. Electricity is the flow of electrons in a metal wire, or some other conductor. Electrons are tiny particles found inside atoms, one of the basic building blocks of all matter. We call the flow of electrons through any conductor a current of electricity. Society relies on the power plants to supply the needed energy source; these power plants burn fossil fuel as the energy source. And you may ask, "What is fossil fuel?" Fossil fuel is fuel found deep in the earth that is used to generate power. These resources have taken millions of years to make. Even though new resources are being formed within the earth today, they will get used up. The students will now have a chance to create drawings or a collage of how their homes or school receive energy. Magazines will be provided for those students wanting to create a collage. The students will use nonrenewable energy sources in there drawings. This activity will assess what the students know about the energy around them.

How much nonrenewable energy does our society use and how much do we need?

How can we find out the amount of energy our society uses? The amount of energy we use is easy to determine, but how much we need is not. We will investigate the states of California, Iowa, Nevada, New Mexico and Louisiana that are using alternative forms of energy, primarily solar and wind energy. The students will also look at states which are producing power from underground geysers. The students will look at graphs showing the European countries which use hydroelectric power. These graphs can be located on the Idaho National Engineering and Environmental Laboratory website (the specific link to the graphs could not be located at the time of publication). I have found through research that many European countries have been very successful in using all forms of alternative energy sources .We will collect data from these places via internet websites such as <http://www.crest.org> which has current policy and specific facts and information about a variety of renewable energy projects. The students will also look at cost analysis of these places and compare the cost of using nonrenewable energy sources to see the savings of these communities. The students will see that there are some very exciting projects created using alternative energy sources: schools which are entirely solar-powered, homes made of wood which are cooled and heated by alternative sources, cars powered by hydrogen, radio stations run completely by solar power and many others. This section will have students explore many websites and books of things and places that are using alternative energy. I will provide a list of approved sites and a small library of books, pamphlets and printouts. The students will use this information as a building block to performing experiments or activities pertaining to alternative energy forms.

What other sources of energy are available?

The students will began by watching the video The Magic School Bus Getting Energized – Using New Energy Sources; this will get the students excited about alternative energy forms. We will discuss the adventures, and answer the following questions: What forms of energy were used? Were the sources nonrenewable or renewable energy? Is there anything in our classroom that is a form of energy? Why is energy important? This video will begin the study of renewable energy sources solar, wind, water, heat (geothermal), plant (biomass) waste products. The students in small groups will now build a solar water heater. The groups will be given the procedures and the necessary materials to build and test their systems. I am sure the students will question why the panel must be painted black. I want them to discover the answer to this question. They should also want to know what would happen if the panel were not painted. Through inquiry the student will see the effects of the sun and why it is a powerful energy source.

What are environmental issues with renewable energy?

In every form of energy there are some issues of concern, but we hope to reduce those issues with changes in the forms we use. The most common problem or concern of an environmentalist is what happens to the land. With the use of solar panels and windmills, lots of space is required. To collect the sun's rays huge mirrors need large tracts of land as a collection site. Wind power also requires land. The average wind farm requires at least 17 acres to produce one megawatt of electricity which would supply energy to only 750 to 1,000 homes. This impacts the natural habitat of plants and animals that live there, and the cost of producing that amount of electricity is about four times expensive than regular natural gas powered plants. Wind farms also cause erosion to desert areas and the natural view. The solar or PV cells use the same technologies as the production of the silicon chips for computers. The manufacturing process uses toxic chemicals. Toxic chemicals are also used in making batteries to store solar electricity through night and on cloudy days. The facilities to produce solar cells are limited throughout the world. There are currently only enough facilities available to produce about 350 megawatts which would only provide electricity to some 300,000 people. That's not enough compared to our needs. Producing geothermal electricity from the earth's crust tends to be localized. The production of energy from the ground cost a bit more than gas powered plants and it also has its concerns: the ground becomes very caustic, causing pipes to corrode and fall apart.

What impacts will depletion of nonrenewable energy have on society?

The resources we are using are replaced by nature, but it will take millions of years. There have been various predictions about the world's supply of crude oil, some economists have stated we should have run out by now, but we are continuing to find as much oil as we are using. With the increases in technology, new oil fields are discovered and small fields are being exploited more economically. People are learning ways to reduce their energy use. Many companies are making sure there is less waste in the production of oil. Economists believe these are all good but we also need to continue development of other options, and increase the technology base to produce energy from our greatest natural resources – the sun, wind and water.

Can society enhance usage of alternative forms of energy?

Society today has to become more creative in saving energy. There are various things which will help slow down the use of nonrenewable resources (oil, natural gas, coal). It is important to save energy because most of the energy we use comes from fossil fuels. It would be impossible to stop using energy, but we can try to use less. Here are some things you can do to save energy in your home or apartment: have your power company do an energy survey of your residence to tell you exactly where you can save. Wear fewer clothes indoors when it is hot outside so parents will not have to run the air conditioner so cold. Turn off lights when you leave a room. Replace regular light bulbs with compact fluorescent lights in rooms where the lights are in use for more than four hours. Turn off your television, radio and computers when not in use. Save gasoline by doing all errands in one trip, or share rides with friends to a destination. Recycle paper, plastic and bottles because making products with recycled material uses about one-third less energy. These are simple things that we can do to conserve energy usage.

Electricity and Heat: Solar-powered

Every minute the sun bombards Earth with enough energy to supply its power needs for years. Yet only two one-hundredths of a percent of all the electricity fed into the United States originates from the sun (Powerlight). Many people think solar energy is a new technology, but capturing this energy source for heat was historically used by many ancient civilizations. Indians designed their homes into cliffs to maximize the solar gains in winter. This technology minimized heat loss at night, and protected them from cold winds. They used small window opening to conserve heat, built structures of heavy stone and clay that absorbed and held the solar heat. There are two ways sunlight may be converted into electric power: (1) directly, in a process called photovoltaic conversion, or (2) by solar thermal conversion, which converts light to heat and then electric power. Devices called photovoltaic cells or solar cells produce electric current directly from sunlight. This is where energy in sunlight causes electric charges to flow through layers of a conductive material to produce useful electric current.

HISTORY OF THE PHOTOVOLTAIC CELL

The development of photovoltaic effect was discovered by Alexandre Edmond Becquerel, a French physicist in 1839. He immersed two metal plates in a solution and observed a small voltage when one plate was exposed to sunlight. The first photovoltaic cells were made of a semi-metallic element called selenium. Selenium cells could convert only 1 percent of sunlight to electric power, so they remained a curiosity for many years. In 1954, scientists at Bell Telephone Laboratories invented the first cell that could produce a useful amount of electric power. The Bell scientists, chemist Calvin S. Fuller and physicists Daryl M. Chapin and Gerald L. Pearson developed a solar cell that was six times better than the selenium cells. A solar cell's efficiency is measured by the percentage of sunlight striking the cell that it turns into electric power. The Bell scientists made their cell from purified silicon, the material used to make computer chips.

The most common type of photovoltaic cells are called crystalline silicon cells, so named because every atom in the cell is part of a single crystal structure. When sunlight strikes the photovoltaic cell, the light's energy forces the negative and positive charges in the semiconductor to separate and to accumulate at electrodes joined to each of the two layers. An electric current will then flow through a wire connecting the two electrons. Today, solar energy is converted using three systems: (1) parabolic trough system, (2) parabolic dish systems, and (3) central receivers. The parabolic trough system is covered with rows of reflectors that move to track the sun. The reflectors focus sunlight to a line that strikes a fluid-filled pipe at the center of the trough. The fluid in the pipe is a heat-absorbing substance that may reach temperatures above 750 degrees Fahrenheit. The heat can be used to make steam to generate electric power or to heat water. The parabolic dish system resembles the parabolic trough systems except that they focus light to a point instead of a line. The dish system reflectors are bowl shaped and can achieve concentrations up to 10,000 times the intensity of normal sunlight. The central receiver systems use sun-tracking mirrors, called heliostats, which reflect light onto a single central tower called a receiver. The receiver is filled with a mixture of molten sodium and potassium salts, which holds heat longer than other fluids. After the molten salt is heated, the system pumps it into insulated tanks. When power is needed the molten salt is pumped into a device called the heat exchanger where it produces steam that turns a turbine. This system operates even when dark or when there is cloud cover. There are several of these receiver systems in California, Spain and Israel.

Although every location on Earth receives sunlight, the amount received varies greatly depending on geographical location, time of day, season and weather conditions. Our society largely relies on the use of fossil fuel because the cost to produce electricity and heat from the sun is too expensive to produce. If solar energy were available in a quantity and at a cost comparable to fossil fuel, it would be a revolutionary change.

But technology is improving efficiency and lowering the cost of solar power. Researchers are continuing to work on making cheaper versions of the silicon cells and create cheaper photovoltaic technology. The manufacturing cost remains relatively high, which is one drawback of solar energy. There are some great facilities using solar energy for obtaining electricity, heating and hot water: The KATO radio station power plant transmits up to 50,000 watts from atop Picuris Peak where it is powered by an array of 140 photovoltaic panels that have been operating since 1991. In the state of Iowa there are more than 6,000 residential structures built to take advantage of solar energy and they save nearly $3,000,000 annually on their heating bills. In 2002, San Francisco transformed their convention center by installing solar panels on the roof with hopes to reduce electricity consumption and slash electric bills by $639,000. Sacramento Municipal Utility built two photovoltaic power plants which cover 20 acres and power 660 homes. In 1987, GM produced the first solar powered sunraycer with solar panels on the exterior or the car. Technology should continue to improve and there will be more and more facilities powered using solar photovoltaic cells (*Solar Energy Information and Links*).

Hydroelectric: Water and Wind

Water Power History

Most machines that make electricity need some form of mechanical energy to get started. Mechanical energy spins the generator to make electricity. In the case of hydroelectricity, the mechanical energy comes from large volumes of falling water. For more than 100 years the simplest way to produce the volumes of falling water needed to make electricity has been to build a dam. Flowing water creates energy that can be captured and turned into electricity. This is called hydropower or hydroelectric power. The water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity. The turbine spins continuously, as long as there is water to drive it. The spent water is returned to the body of water. Scientists believe that hydropower will be a cleaner alternative to fossil fuel. Hydrogen can be made from water, and when burned, turns back into water. This can occur because water is composed of two parts hydrogen, and one part oxygen. The hydrogen atoms are separated from the oxygen atoms through a process called electrolysis and then they recombine with oxygen atoms and turn back into water. Electricity can make hydrogen, and hydrogen can also make electricity. Together they create an energy loop that is 100 percent renewable. In areas where there is a steady source of running water, water generators can provide the most reliable and constant source of power. But there has to be a way to keep the system from freezing during winter. It is believed that a heating system should be installed in the water intake system. The Hoover Dam on the Colorado River is the largest generator of hydroelectricity in the United States. The future of hydrogen has gained momentum, the oil companies rushed to buy interest in technology companies developing ways to refine and store the new fuel. Texaco, Shell, BP (British Petroleum), Chevron, Exxon Mobil, Ford and General Electric have all devoted more than $270 million to hydrogen research (*Shell Hydrogen signs agreement with Vandenborre Technologies to develop and market home hydrogen refuelling product*).

Wind Power History

Wind power is the energy associated with the air that moves over the earth's surface. Wind is a renewable energy source that cannot be used up. Wind power is one of the most simple and utilized natural power sources on earth. Wind power is very appealing as a modern source of power because it is a force that is always free and existing. Wind provides clean nonpolluting energy that can supply power from plants that will generate enough energy for many small towns and cities. Wind energy is kinetic energy (energy of movement). People have harnessed the power of the wind to do work for thousands of years. The Egyptians used wind-powered sailing ships as early as 2800 B.C. Most early windmills used rotational energy to operate machinery. By the 17th century, the Netherlands had become the world's most industrialized nation by extensive use of wind power to drive trading ships, to power grinding mills, and to pump water from lands that were once beneath the sea. Wind power was first used to generate electric power in America in the 1850s to pump water and turn sawmills. The use of wind power represented 1.4 billion horsepower-hours-of-works. However the enactment of the Rural Electrification Act after WWII brought an end to the growing reliance on wind energy (Franklin Institute). As the United States' dependence on oil increased during the early 1970s, focus was placed on using the energy of the wind to generate electric power once again.

Wind generates electrical power by turning propeller wheels on wind generators. It is the same principal behind the child's toy called a pinwheel. These propeller wheels in turn transfer the energy they gained to generate power. The generator generates electricity and the electricity can be stored or used. In order for a wind turbine to work efficiently, wind speeds usually must be above 12 to 14 miles per hour. These wind-generating towers are generally 20 feet tall and must be out of the way of tall buildings or mountains that can obstruct the wind. The size of the wheel determines the output of electricity. The larger the wheel gets the more power it can generate. Like solar power, harnessing the wind is highly dependent upon weather and location. Windmills and wind turbines were used to extract wind power; only part of the kinetic energy of the wind is transferred to the blade of the device. Today there are wind turbines in 27 states, generating enough electricity to power over 1.3 million average American homes. Texas produced the largest amount of electricity from the wind, second to California (Franklin Institute). There are various factors that limit the extraction and successful use of wind power, limits on the size of wind powered devices, availability of land on which to erect the devices, people oppose the devices because they feel it's a danger to birds that fly by the blades, wind speeds vary greatly over the earth's surface; if there were calm entire cities could be without power, wind plants require use of large areas of land and the power plants generate extremely loud sounds. There are many parts which must be improved but we must continue the search and use of wind turbines combined with other sources.

Geothermal Electricity and Heat

The earth's interior, like the sun, provides heat energy from nature. Geothermal energy is the heat from the earth. This heat yields warmth and power that can be used without polluting the environment. The heat from the earth's core continuously flows outward. It transfers to the surrounding layer of rock, the mantle. When temperatures and pressures become high enough, some mantle rock melts, becoming magma. Then, because it is lighter than the surrounding rock, the magma rises, moving slowly up toward the earth's crust carrying the heat from below. This magma sometimes reaches all the way to the surface, where we know it as lava. But most often the magma remains below the earth's crust heating rocks and water. Some of this hot geothermal water travels back up through cracks and faults and reaches the earth's surface as hot springs or geysers.

Geothermal energy has been used for direct heating purposes since ancient times; its use for the generation of electricity began only in the 20th century. 10,000 years ago, Native Americans used geothermal energy for cooking and medicine. The Romans also used this form of energy to heat buildings. The first experiments to make use of geothermal energy to generate electricity occurred in Larderello, Tuscany, Italy in 1904. Since 1960 France has used geothermal energy to provide heating to 200,000 homes. Geologists, geochemist, drillers and engineers continue to explore and test to find locations of underground areas that contain geothermal water, so they will know where to drill geothermal production wells. When the sites are located and drilled hot water and or steam travels up the wells surface and can be used to generate electricity in power plants. Most power plants need steam to generate electricity. The steam rotates a turbine that activates a generator, which produces electricity. The used geothermal water is then returned down an injection well into the reservoir to be reheated, to maintain pressure, and to sustain the reservoir. There are only two known underground resources of steam in the United States: The Geysers in northern California and Yellowstone National Park in Wyoming. The first modern district heating system was developed in Boise, Idaho. There are over 271 U.S. communities with geothermal resources available for use. Modern district heating systems also serve homes in Russia, China, France, Sweden, Hungary, Romania and Japan. The world's largest district is in Reykjavik, Iceland once very polluted has now become one of the cleanest cities in the world. With some creative thinking geothermal energy has unlimited ways in which it can be used. With improvements in technology, much more power will become available (*A History of Geothermal Energy in the United States*).

LESSON PLANS

Lesson Plan One: What is Energy?

This lesson, which takes one class period, will introduce students to the many views on energy. It will assess students' current knowledge about energy, introduce the definition of energy, identify the different forms of energy and discover the numerous items in our everyday lives.

Objectives
SCI.5.8A – The students will be able to differentiate among forms of energy including light, heat and electrical. Identify that energy comes in many forms.

Procedure
Have students write their definition of energy. Once completed, have them draw examples of what they think energy is. I will then do Activity I, which will show the many items used in everyday life that are energy sources.

Assessment Questions
1. What is Energy? Energy is the ability to do work, cause change and movement.
2. How is energy used? Energy is used to power everything we do.
3. Why is energy important? Society would not be able to perform many of the everyday functions we do everyday.
4. Where does energy come from? Energy comes from one main source the sun, and is transformed into other forms.

Homework
Students will be given a list of vocabulary words that are used in this unit. Students will define these words as a homework assignment, which will serve as an introduction to Lesson Plan Two. Solar, biomass, fossil fuel, hydroelectric, magma, Geysers, turbine, nonrenewable, greenhouse effect, and extract, turbine, geothermal and photovoltaic.

Lesson Plan Two: Introduction to Alternative Forms

This lesson takes two class periods and will introduce students to renewable and nonrenewable energy sources. List items in each group; come up with a classroom definition of both.

The students will watch the video *The Magic School Bus: Getting Energized*. As a group we will discuss the adventure taken by the students in this video and what forms of energy were used. Students, still in a group, will discuss the homework vocabulary words, and then explain how each of these terms relates to energy.

Objectives
- SCI.5.8A – Differentiate among forms of energy including light, heat and electrical. Understand that energy cannot be created or destroyed, only converted into other forms.
- SCI.5.8C – Demonstrate that electricity can flow in a circuit and can produce heat, light, and magnetic effects. Demonstrate that a simple circuit controls the movement

of electrons and can produce heat. Know that electricity is generated at power stations where a turbine driven by water, steam or wind power generates electricity.

Materials

- Video – *The Magic School Bus: Getting Energized*
- Chart listing what we learned about nonrenewable and renewable energy forms.
- Chart listing what students want to know about alternative energy forms.
- Computer with an Internet connection

Procedure

Go to the Department of Energy's interactive site for kids <www.eere.energy.gov/kids>. Students, in groups of four, will be assigned one of the following renewable energy sources: Solar, Wind, Geothermal, Biomass and Hydropower. They will go through the interactive site on their topic and afterward write a one-page paragraph on their topic which will be presented to the class.

Assessment Questions

1. Why some energy sources are called renewable?
   A. They are clean and free to use.
   B. They take a long time to be remade by nature.
   C. They do not produce pollution.
   D. They can be remade by nature in a short time.
2. In the United States, which energy source produces most of our electricity?
   A. solar
   B. natural gas
   C. coal
   D. petroleum
3. Energy that is never used up is called___________.
   A. electricity
   B. solar power
   C. renewable energy
   D. nonrenewable energy
4. All energy comes from the ____________.
   A. electricity
   B. moon
   C. sun
   D. power plants
5. People believe that ____________ will be the long-term solution to our energy problems.
   A. electricity
   B. geothermal power
   C. nonrenewable energy
   D. renewable energy

6. Which of these is another renewable source of energy?
   A. uranium
   B. fossil fuel
   C. nuclear energy
   D. solar energy
7. What make an energy source nonrenewable?
   A. It's nonrenewable if it's created in power plants
   B. It's nonrenewable when it is overdue like a library book
   C. It's nonrenewable if it makes use of water
   D. It's nonrenewable if it can be used up

Lesson Plan Three: Let the Sun Shine
This lesson will cover how the sun is our major source of energy. Using the sun's power to produce solar energy turning it directly into electricity is not efficient today; however, solar energy can best be collected as heat.

Objectives
SCI.5.8C – Understand that energy is everywhere and energy changing from one form to another is behind most changes in the environment. Demonstrate that a simple circuit controls the movement of electrons and can produce heat.

Background Information: The Sun
The sun is the closest star to earth and is the primary source of all energy ever harvested on the plant. All forms of energy, from coal to oil, and even wind, come directly from the sun. This amazing star has been energizing earth ever since the beginning of time, about 4.3 billion years ago. The composition of the sun is a simple mix of mostly hydrogen and helium. The large amount of hydrogen on the sun allows fusion to take place deep within the suns core.

I will read the article "Good as Gold: The Silicon Solar Cell Turns 50," by Perlin, Kazmerski, and Moon. It provides information on the invention of the photovoltaic cell (PV) which is used to produce electricity and heat in various ways.

Procedure: Radiation and the Transfer of Energy
The students will see that solar energy can best be collected as heat. The students will recognize that light colors are less heat absorbent than dark colors and those dark colored objects absorb energy faster than light colored objects. Lessons Five and Six will give students the understanding of how much energy the sun produces. One of the most interesting things about the transfer of energy by radiation is how the characteristics of the material which is absorbing the energy affect the amount of energy transferred. In these activities we will compare the ability of different substances to absorb and lose energy to change temperature.
Students will graph the data from the investigation in Activity III, labeling the lines showing the temperatures of the five different materials.

Lesson Plan Four

Introduction
Pre-assessment of students' knowledge of energy. Observe different types of energy sources. Discuss why these items are considered energy sources.

Materials
- Picture of the Sun
- Piece of fruit or vegetable
- Container of vegetable oil
- Piece of firewood
- Piece of charcoal or coal
- Container of motor oil
- Gas lighter
- Cup of water and an empty cup
- Child's pinwheel
- Picture of lightning
- Light bulb
- Piece of discarded trash
- Battery

Energy Sources

Sunlight
Point to the picture of the sun. The light that comes to the earth from the sun is pure energy. The sun is the original energy source. Nearly all other sources of energy originally got their energy from the sun. Organic matter, such as plants, convert solar energy into leaves, fruit and flowers. Animals which eat organic matter convert the energy into body mass. When animals die, their energy is decomposed and over time becomes stored as oil, coal or natural gas.

Food
Hold up the fruit or vegetable. Food is the source of energy used by people. Food we eat is digested, and that stored energy is used by the body to keep the heart beating, the blood pumping and the body growing.

Organic Oils
Hold up the bottle of vegetable oil. Vegetable oils, like olive oil, corn oil, and others are used for cooking. Animal oil, like that from whales, seals and livestock, was used in the past for lighting lamps as well as waterproofing.

Wood
Hold up the piece of wood. Wood comes from trees which are plants. The plants get their energy from the sun. When trees are cut down and burned, they release their energy in the form of heat. Many homes are heated with wood burning stoves.

Coal
Hold up the piece of coal or charcoal. Coal is burned to heat homes and run electrical machinery. About 20% of the energy we use comes from coal.

Oil
Hold a clear container of motor oil, which is a petroleum product burned to fuel motor vehicles and heat homes. About 45% of energy used comes from oil.

Natural Gas
Hold the lighter and light it. The fuel used in the lighter is not the same as the natural gas used to heat homes, but the lighter can be used as an example. Most energy used today comes from fossil fuels.

Other Energy Sources
The following energy sources do not require the sun. They are derived from other aspects of the earth's ecosystem.

Water
Pour water from one cup to another, simulating a waterfall. Water is not an energy source, but water is used to generate energy. Water falling downhill is used to run turbines, which generate electricity. This is called hydroelectric power. About 5% of the world's power is now produced by hydroelectric dams. A similar type of energy comes from geothermal energy. Pockets of boiling water under the earth's surface send steam to the surface of the earth. This hot water can be used to generate electricity.

Wind
Hold up the pinwheel and blow on it. Winds that blow can be used to turn windmills, which generate electricity. Windmills have been used for centuries in some parts of the world and in the US.

Electricity
Hold up the picture of lighting and the light bulb. An electrical storm contains a great deal of natural electrical energy. Benjamin Franklin first proved that lightning was electricity. Today the electricity we use today was created by other sources, not the energy released by lightning.

Refuse-derived fuel
Hold up the discarded trash. Now we are able to extract energy from garbage. Garbage is burned in a waste-to-energy facility. As it burns, water pipes are heated. The hot water is used to generate electricity.

Chemical energy
Hold up the battery. Batteries create energy through chemical reactions. When different chemicals react with one another, energy is released. Eventually the reaction stops, and the battery must be replaced.

Lesson Plan Five

Objectives
Students will recognize that light colors are less heat absorbent than dark colors. Students will know that the sun is a source of energy. The students see that solar energy can best be collected as heat. This activity will have the students collect and store the sun's energy in the form of heat.

Materials
- Two plastic bottles
- Black flat paint
- White paint
- Several small balloons

Procedure
The Black and White bottle experiment is performed with the two plastic bottles. One bottle is painted white and the other one painted black. Place the open end of one small balloon on the mouth of the white plastic bottle and the same on the black bottle. Make sure the balloon forms a tight seal. Now place both bottles in bright sunlight. Within a few minutes, the students will notice the balloon on the black bottle will start to expand. The balloon of the white bottle will remain limp. Have a student touch the black bottle to notice that it is warm. Have the same student touch the white bottle to notice that it is much cooler.

Questions
1. Why do you think the balloon on the black bottle expanded?
2. Does heat make air expand?
3. Does a black object get warmer than a white object?
4. What would be a good color to paint your car if you wanted to stay cool in the summer?

General Information
Our sun is an average sized star and it has been burning for about 4.5 billion years. Few people realize this is a source of energy that does not pollute. About 4 million tons of the sun's matter turns into energy every second.

Lesson Plan Six

Objective
Students gain an understanding that dark colored objects absorb energy faster than light colored objects.

Background
While solar energy can be used immediately to warm a house, it is often stored as heat to be released slowly into an area to be heated. Solar collectors are usually dark, as dark colors absorb heat more rapidly than light objects. Water is often heated by solar energy and used to store the energy. Water warms slowly, but holds its heat and cools slowly. In this activity students not only determine the fastest absorbers of solar energy, but the slowest releasers of solar energy. This activity should be done outside on a sunny day when the sun is high in the sky.

Materials
- Lamp with a 150 watt bulb, or the sun
- Bottom 3 cm of 5 Styrofoam cups
- Light colored sand
- Dark colored dirt
- Thermometers
- 1 sheet of graph paper

Procedure
Determine the change in temperature from the absorption of radiant energy in five different substances: Water, dry light sand, wet light sand, dry dark dirt, wet dark dirt

1. Use five cups, one with each of the materials listed above.
2. Arrange the cups in as small a circle as possible without having them touch each other.
3. Place a thermometer in each cup so the bulb is 0.5 cm below the surface of the material. (You will need to hold or clamp the thermometer in that position in the water.)
4. Place a lamp 20 cm above the containers and directly over the center of the circle.
5. Read and record the temperature of each material just before turning on the lamp. Turn on the lamp and record the temperature at regular intervals of one to five minutes. Turn the lamp off and continue to record the temperature at regular intervals

of one minute for five minutes. Record your results in a table. Think about what you will measure and design a good table in which to record your results.
6. Graph the data from the investigation. Label the lines showing the temperature of the five different materials.

Questions
1. During the five minutes the light was on, where did the energy come from to change the temperature of the substances in the cups?
2. Of the two wet solids, which warmed the fastest? What characteristic caused it to absorb more radiant energy?
3. Which two materials warmed the fastest? Explain why they warmed up more rapidly than the other materials.
4. Where did the heat energy go when the material cooled?
5. Which material cooled off most rapidly after the light was turned off? Explain why it cooled most rapidly.

Lesson Plan Seven

Objective
To give students an understanding of the complexities involved in the global warming phenomenon.

Background
The earth's temperature is the result of sunlight penetrating the earth's atmosphere and warming the planet. Some of the light energy is reflected; however, certain gases in the atmosphere trap the heat energy after it is reflected off the surface of the earth. This trapping of sunlight energy creates the greenhouse effect. The primary concern with the greenhouse effect is that artificial gases added to the air as pollutants are increasing this effect and slowly causing the earth's temperature to increase.

Materials
- Glass jar
- Thermometer
- Cardboard to screen thermometer from sun
- Sun

Procedure
The place where you have most likely seen the greenhouse effect is not in a greenhouse but in a car. If you have ever stepped into a car that has been tightly closed and sitting in the sun for some time, you have noticed how much warmer it is inside than outside the car.

1. Place a small thermometer inside a glass jar
2. Insert a piece of cardboard in the jar to shade the thermometer.

3. Place the jar in the bright sunlight with the sun facing side perpendicular to the sunlight
4. Watch the temperature in the jar for a few minutes.

Questions
1. What happens to the temperature?
2. Can you get the temperature to rise higher by covering the jar with insulation?
3. Does the angle that the sun facing side of the jar have any effect on the rate at which heat is produced in the jar?

Lesson Plan Eight

Objective
The students will see the concept of how energy is created through an electrical current. This is the same way that turbines are used to generate electricity**.**

Background
The movement of the magnet in and out of the tube coiled with wire causes an electrical current to flow through the wire. This is the same method used to generate just about all the electricity people use. The battery takes chemical potential energy and converts it to electrical energy. The solar cell takes radiant energy from the sun and converts it to electrical energy.

Materials
- Compass
- A strong magnet
- 2 Meter section of insulted wire. Be sure it is thin enough so that it bends, yet strong enough to hold its shape.
- A working flashlight
- Some kind of tape
- A tube from a roll of toilet paper
- C or D cell battery

Procedure
1. Start by stripping a small bit of insulation off each end of the wire.
2. Wrap the wire a bunch of times around the compass. Leaving about 10 centimeters of wire on one end and at least a meter of wire on the other end.
3. Make sure you can still see the compass needle underneath the wire
4. Tape the wire in place
5. Make sure the compass isn't near the magnet, or any other magnet (phones, stereo speakers have magnets)
6. Place the wrapped compass on a flat surface, the compass needle should point north

7. With the compass in the correct position touch the free, stripped end of the wire to the battery terminals, tape them in place. The compass needle should deflect, if it doesn't check your battery. With a good battery and the correct alignment the compass needle will deflect. The battery cause electrical current to flow through the wire.
8. Now remove the battery and cut the toilet paper tube in half.
9. Wrap the long free end of the wire around one half of the tube, leave enough wire so you can twist together the stripped ends and be able to place the tune 30 centimeters from the compass.
10. Move the magnet in and out of the center of the tube, as you do watch the compass needle. The compass needle should move a tiny bit and only while the magnet is moving.

Lesson Plan Nine

Objective
The students will make solar collectors and experiment to see which ones heat water most effectively.

Background
Solar energy is a renewable resource that can be used in various ways. One of the most common uses is heating water.

Materials
- Cardboard box no more than about 10 cm deep – the size of a small shoebox
- Aluminum foil
- Black poster paint
- Small sealable heavyweight plastic storage bags (one for each box)
- Water
- Thermometer(s)
- Duct tape or other heavy-duty tape.

Procedure
1. Cut pieces of aluminum foil large enough to cover the bottom of each of the boxes.
2. Using the poster paint, paint half of the aluminum foil pieces black.
3. Once the paint is dry, tape the foil onto the bottom of each box. This is the solar collector.
4. Fill each plastic bag with approximately one cup of cold water and seal tightly.
5. Tape a bag of water to the foil in the bottom of each box.
6. Take each box outside and place in bright sunshine. You will probably want to prop the boxes up against a wall or a board, so that the water can absorb the maximum amount of solar energy.

7. After one hour, carefully remove the bags of water, unseal them partially and insert the thermometer. Assign one student to record the temperatures from each collector, noting whether the surface of the collector was painted black or not.
8. Discuss the results with students and ask them to explain why most solar collectors are painted black.

Extension

Solar Car
A kit will be purchased from Sun Wind Soar Industry <http://www.sunwind.ca>.
The step-by-step instructions will be provided so the students can use this as a Science Fair Project.

Building the Best Windmill
Students will also build a windmill from K'Nex© pieces, creating designs that can test their hypothesis of how to catch the wind's kinetic energy.

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