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Fossil Fuel Sources, Usage and Alternatives: What Are the Options?

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by Susan S. Van Biersel

Introduction

This unit has been written as part of a team effort with a colleague, Crystal LaVoie, to develop two complementary curriculum units, focusing on energy and the environment. The units are designed to be taught within a pilot Integrated Science curriculum for ninth and tenth graders during the 2004-2005 school year at New Haven Academy. New Haven Academy (NHA) is a new (founded 2003) interdistrict magnet high school, serving students from New Haven and 25 surrounding communities. Currently consisting of 65 ninth graders, NHA will eventually become a school for grades 9-12, adding a ninth grade each year until 2006. NHA is a member of the Coalition of Essential Schools, an organization whose mission is "to create and sustain equitable, intellectually vibrant, personalized schools and to make such schools the norm of American public education." In keeping with this vision, NHA's specific mission is to "provide a rigorous education that prepares all students to succeed in college".

The Integrated Science format will combine Physical, Earth, and Life Science. This unit will be used as a link between the Physical and Earth Science segments. Ms. LaVoie will introduce energy at the fundamental level first. Students will investigate the relationship of energy to work, and be introduced to the first law of thermodynamics. The potential, kinetic and mechanical forms of energy will be introduced and explored. Engine models will be introduced, and discussed. Ms. La Voie's unit will culminate with an introductory lesson on the internal combustion engine.

Following Ms. La Voie's unit, I will introduce this unit, which will begin with a more detailed look at the internal combustion engine. We will then move on to a more in-depth look at the fossil fuels oil, coal and natural gas. Sources, usage rate and sustainability of fuels will be covered as part of the discussions. We will address impacts of fossil fuels on the environment, and possible solutions for reduction thereof.

Throughout the course of both units, students will be asked to relate the usage of energy and resources to their daily lives. Energy conservation will be emphasized, and we will touch on the political implications of energy policies.

Unit Objectives

The overall goal of this unit is to explore different fossil fuel sources, present-day usage of fossil fuels, and the impact they have on the environment. We will also investigate alternatives to fossil fuels, and possible solutions to the negative impacts fossil fuels have on the environment. Students will explore simple engine models. There will be significant emphasis placed on trying to open the students' eyes to the critical energy situation we are in today, and how it will impact their lives if not seriously addressed.

The unit has been designed for a ninth and tenth grade Earth Science section, however, with modifications could easily lend itself to most any level science curriculum. Parts of the unit could also be molded to fit into a twentieth century history class, examining changes in American life since the industrial revolution and the advent of the automobile. A political science curriculum might incorporate sections of the unit as they examine the domestic and international implications of energy policies.

This unit will closely follow the standards set forth by the New Haven Public Schools science curriculum. Under content standard SRC 9-10.1, scientific inquiry, this unit will address the following points:

- Students will be able to identify questions and that can be answered through scientific investigation
- Students will be able to seek relevant information in books, magazines and electronic sources of information.
- Students will be able to use appropriate tools and techniques to gather, analyze and interpret data.

The unit will also address the following standards set forth under standard SRC 9-10.2, literacy in science education:

- Students will be able to communicate ideas and support arguments about science-related matters using relevant science vocabulary, evidence and logic.
- Students will be able to develop the interpretive, analytical and critical capacities needed for reading and writing various scientific texts.

Specifically, these content standards will be learned and used within the following strands:

1. High School Science Strand I: Alternative Energy Sources: HIS.3: How can we meet global energy needs?
2. High School Science Strand II: A Balanced Environment: HSII.3: The environment-how can we

sustain its health?
3. High School Science Strand IV: Organic & Synthetic Polymers: HSIV: Carbon: what makes it the building block of organic and synthetic materials?
4. High School Science Strand VI: Understanding Evolution: HSVI.2: Earth history: how and what can we learn from it?

Overview

For hundreds of years, man has found ways to harness energy, such as using animals to do work or designing machines of varying sophistication to tap the power of wind or water. The advent of the Industrial Revolution in the late 1800s, however, was accompanied by the widespread and growing use of fossil fuels such as coal, oil, and natural gas. It was at this point in time in America that the total work output of engines surpassed that of work animals1. As the United States industrialized, coal began to replace wood as a primary fuel. As industrialization proceeded, petroleum and natural gas replaced coal for many applications. The United States has since relied heavily on these three fossil fuelscoal, petroleum, and natural gas for the majority of their energy needs.

Until the 1950s, the United States was nearly energy self-sufficient. However, during the 1960s, energy consumption began to outpace production, largely due to the increased use of the automobile. For the following three decades, the gap between domestic energy production and consumption has continued to grow. This has resulted in America’s dependence on other countries for some of its energy needs, in particular, petroleum. Since the mid 1980s, the United States has imported nearly half of its petroleum needs. Some of it has come from countries other than those in the Middle East, such as Mexico, Venezuela, and Nigeria. In 1994, U.S. oil imports broke through the halfway mark at 50.4 percent, the first time that our foreign-oil consumption exceeded that of our domestic production. All of this, of course, has had serious international implications. As quoted by Harvey Blatt, in one of his recent college textbooks, “Any industrial nation with a petroleum-based economy that imports half its oil is on shaky ground regarding oil price and stability of supply”2

Historical Perspective

We will open the unit by touching briefly on the political implications of energy policy. Particularly given the current situation in the Middle East, an entire unit could certainly be written on that issue. However, an effort will be made at the onset of the unit, and throughout, to give the students somewhat of an historical perspective on U.S. energy policies, what broad-range effects they can have, and how they do, indeed, affect their everyday lives (look at today’s gas prices). Students will compare and contrast the energy policies of the last four Presidential administrations, beginning with Ronald Reagan (1980-1988). The platform of the Reagan administration was to downplay the importance of government responsibility for dealing with the energy problem. The ensuing Republican administration of President George H.W. Bush (1988-1992) continued the

Reagan policies of minimizing government regulation of the energy industry. The following Democratic administration of President Bill Clinton (1992-2000) returned government involvement to energy and environmental issues. Several major energy bills were proposed by this administration, but were defeated by the Republican Congress in power. Nevertheless, the Clinton administration did increase funds for alternative energy research, mandate new energy efficiency measures, and enforce emission standards. The major energy policy goals of the following (and current) Republican administration of President George W. Bush (2001-present) were "to increase and diversify the sources of America's oil supplies and to make energy security a priority"3. To date, President Bush has not demonstrated an environmentally friendly agenda. He staunchly refused to sign the Kyoto Protocol, an international effort to reduce greenhouse gas emissions and air pollution. He also encouraged efforts to permit drilling in environmentally sensitive areas such as the Arctic National Wildlife Refuge in Alaska. It will be interesting to see what repercussions the Iraq war, a war he lobbied hard for against domestic and international opposition, will have on U.S. energy needs.

Engines and What Drives Them

After setting this historical perspective, we will review the internal combustion engine, which was begun in Ms. La Voie's unit. We will discuss human's increased dependence on engines in the last fifty years. Students will be asked to reflect on what their lives would be like without engines and machines. One activity might include a series of interviews with people who know what life was like before America was an automobile society. This could possibly involve a trip to a local retirement center or nursing home, which might jump-start a community outreach project for the students. Outputs might include essays, journal entries or even poems.

Our specific lessons on the internal combustion engine will focus on the four-stroke and two-stroke engines. We will review the premise that a gasoline-fueled engine is a mechanism designed to transform the chemical energy of burning fuel into mechanical energy. In operation, it controls and applies this energy to mow lawns, cut trees, and propel tractors, trucks and cars4. The four-stroke cycle engine is probably the most common engine type in use today. It powers almost all cars and trucks. Two stroke engines are used to power chainsaws, line trimmers, outboard motors, snowmobiles, jet-skis, light motorcycles, and model airplanes. We will discuss the specific fuel usage and the environmental impacts of the four-stroke and two-stroke engines. We will also look at the evolution of engine design, and efforts that have been made to reduce pollution.

Fossil Fuel Facts

Next the unit will take a step back, so to speak, and examine the ways in which fossil fuels, the fuels used to power the engines studied, are formed. Fossil fuels are "organic chemicals created by living organisms millions of years ago and buried in sediments, where high pressures and temperatures concentrated and transformed them into energy-rich compounds"5. Currently, fossil fuels account for the great majority of the world's energy use. Students will compare and contrast coal (a solid), petroleum (a liquid) and natural gas. We will study the geologic timetable involved in the formation of these fuels. Emphasis will be placed on the fact that due to the extremely long time involved in forming these fuels, they are essentially *nonrenewable* resources. Students will research current reserves of fossil fuels, versus rate of consumption. Location of current reserves will be researched, particularly domestic vs. foreign. It will be noted that fuels are not distributed evenly throughout the world. For example, about 60 percent of known oil supplies are located in a small area in the Middle East. The United States has just 2 percent of the world's oil supplies, but about 25 percent of the world's coal supplies6. One startling fact we will look at is, given the current rate of consumption and available reserves, we may "run out of gas" (crude oil reserves will be depleted) in as little as 30-50 years!7

Following the study of fossil fuel formation, the students will explore the different methods by which the fuels are discovered, attained (e.g. mining, drilling), processed, and ultimately put into use. The economic and environmental impacts will be explored. The study of discovery and attainment of petroleum, gas and coal will offer an interesting look at geography and geology on a national and an international level. The lessons on processing and usage will provide a natural progression into the impacts on the economy and environment.

Environmental Impacts of Fossil Fuels

Obtaining energy by burning fossil fuels creates environmental problems of immense global proportions. It produces oxides of carbon, sulfur, and nitrogen, soot and fine-particulate ash. Carbon monoxide (CO), an oxide produced by combustion of all fossil and plant fuels, is converted to carbon dioxide (CO_2), which contributes to global warming. Global warming is "an enhancement of the greenhouse effect of the earth's atmosphere, resulting in an increase of the annual average surface temperature of the earth on the order of 0.5-1 degree Celsius since the middle of the nineteenth century" 8. Most of that warming has occurred within the last two decades. Global warming is caused by the increasing accumulation in the atmosphere of predominately CO_2 and other gases [specifically CH_4, N_2O and chlorofluorocarbons (CFCs)]. Together these are called the "greenhouse gases". Many scientists regard anthropogenic (human-caused) global climate change to be the most important environmental issue of our times. Since pre-industrial times atmospheric concentrations of CO_2, CH_4 and N_2O have increased by over 31 percent, 151 percent, and 17 percent, respectively. Carbon dioxide is by far the most important cause of anthropogenic climate change, contributing 64 percent of the world's global warming problemmore than all other greenhouse gases combinedd9.

It is estimated that at the current rate, the average annual surface temperature of the earth could increase 2-3 degrees Celsius by the end of the twenty-first century. This increase is enough to cause significant impact on human habitat and ecological systems. Speculated implications include increasingly severe weather, more sudden temperature swings, droughts, floods, heat waves, wildfires, and thunderstorms. Food and water supplies would be threatened. The world's glaciers would melt enough to cause sea levels to rise and low-lying areas such and the Mississippi Delta to flood. Tropical regions would expand, allowing insects that carry diseased such as malaria, dengue fever, and the West Nile virus to spread to places like Florida, Georgia or even New York10.

Burning coal also releases sulfur oxides (SO_x) to the atmosphere, where they form environmentally injurious compounds. Nitrogen oxides (NO_x), mostly NO and NO_2, are products of combustion in not only auto engines, but also power plants. The nitrous oxides are the precursors of the photochemical oxidants, ozone and peroxyacetyl nitrate (PAN), which is associated with smog. Water and oxygen in the atmosphere combine with SO_2 and NO_2 to form sulfuric acid (H_2SO_4) and nitric acid (HNO_3), the main components of acid rainrain with an elevated pH, mostly due to environmental factors such as pollutants in the atmospheree11. The students will study these adverse environmental impacts, and hopefully gain an appreciation of the ways in which their personal lives are affected by them.

Solutions

The final sections of the unit will focus on possible solutions for reducing negative impacts by fossil fuels on the environment, and possible alternative energy sources for the future. As Blatt states in his text, fossil fuels are “ major pollutants and need to be phased out for that reason alone, without even considering the serious economic cost of importing half our needs. We have no choice but to begin the switch to alternative fuels. This is inevitable. As expensive and disruptive as the changeover will be now, it will only be more expensive and just as disruptive later” 12.

Fossil fuels now provide about 79 percent of all commercial energy in the world13. In many of the world’s wealthier countries, much of this energy is consumed by transportation. In the U.S., transportation consumes 30 percent of total energy used, and 63 percent of all petroleum. We also own 40 percent of the world’s cars. In light of these facts, we will spend time during the unit discussing several alternative *transportation* fuels now available. Three alternative fuels we will discuss will include methanol, ethanol (both largely renewable) and propane (nonrenewable). All three of these fuels offer a more environmentally friendly transportation alternative than gasoline.

For more than thirty years, methanol (also known as “wood alcohol”) has been the fuel of choice at the Indianapolis 500. Most methanol-fueled vehicles use M85, a mixture of 85 percent methanol and 15 percent unleaded gasoline. Produced as a liquid, methanol is currently made from natural gas, but it can also be made from a wide range of renewable sources, such as wood or waste paper. Most methanol-powered vehicles are fuel-flexible, meaning they can use 100 percent gasoline if methanol is not available. There are currently more than 15,000 M85 vehicles in operation, primarily in California and New York. Potential environmental advantages offered by methanol compared to gasoline include lower nitrogen oxide emissions, no particulate matter formation, and lower overall volatile organic compound (VOCs) emissions14.

Ethanol-fueled vehicles date back to the 1880s, when Henry Ford designed his popular Model T to operate on either ethanol or gasoline. Ethanol is essentially 100 percent pure grain alcohol, and is produced by fermenting plant sugars. It can be made from corn, potatoes, wood, waste paper, wheat, and brewery waste. More than 90 percent of U.S. ethanol production today comes from corn. Pure ethanol is rarely used for transportation; it is usually mixed with gasoline. The most popular blend for light-duty vehicles is known as E85, which is 85 percent ethanol and 15 percent gasoline. As of March 2002, American automakers were producing a variety of automobiles, light-duty pickup trucks, and minivans known as flexible-fuel vehicles (FFVs). These vehicles can operate on any combination of ethanol and gasoline by automatically sensing the percentage of alcohol in the fuel tank, and adjusting the engine’s parameters accordingly. In January 2002, the U.S. Postal Service (USPS) made the largest purchase of FFVs by a federal government agency, agreeing to buy nearly 23,750 vehicles powered with up to 85 percent ethanol. Compared to conventional gasoline, ethanol produces fewer total toxics, reduces VOC emissions by 15 percent, and particulate emissions by 20 percent15.

Propane (otherwise known as Liquefied Petroleum Gas or LPG) is a byproduct of natural gas processing and petroleum refining. More than 60 million Americans use propane gas for everything from heating and cooling homes and businesses to powering barbecue grills. Propane has been used as a transportation fuel since the 1940s. Today, auto manufacturers offer a variety of light- and medium-duty propane-powered vehicles, primarily used by vehicle fleets. There are more than 350,000 vehicles on our roads today, including taxicabs, police cars, and school buses. Compared with gasoline, propane can lower carbon dioxide, carbon monoxide, and other toxic emissions16.

The “Renewables”

The main *renewable* alternative energy systems include solar and nuclear power, hydroelectric power, biomass energy, wind energy and fuel cells. During this final section of the unit, by way of introduction and exposure, we will touch briefly on each of these energy options. Students will do cursory research on how and to what extent these technologies are in use today, and what the possibilities are for the future. We will narrow our scope, however, to address solar and wind energy in particular.

Solar Power

As one author describes it, the sun is "a giant nuclear furnace in space, constantly bathing our planet with a free energy supply." Much of the solar energy arriving at the top of the earth's atmosphere is absorbed or reflected by the atmosphere (more at high latitudes than at the equator). However, the average amount of solar energy reaching the earth's surface is some 10,000 times all the commercial energy used each year17. Unfortunately, until this century, we have not devised an efficient and cost-effective way in which to capture and convert this tremendous infusion of energy. The encouraging news is that great strides have been made in just the last 25 years toward developing workable ways to utilize this wonderful source of energy. During this section of the unit, we will examine the following:

- Passive Solar Heating: This is the simplest and oldest use of solar energy, which basically involves the adsorption of solar energy directly into a building in order to reduce the energy required for heating. This method uses natural materials or structures with no moving parts to simply gather and hold heat. An example of adapting this principle is a glass-walled "sunspace" or greenhouse on the south side of a building.
- Active Solar Heating: Active solar systems generally pump a heat-absorbing medium such as air, water or anti-freeze through a small collector, rather than passively collecting heat in a stationary medium. Active collectors are usually located adjacent to or on top of a building.
- Solar Thermal Engines: These are an extension of active solar heating, usually using more complex collectors to produce temperatures high enough to drive a steam turbine to produce electric power.
- Photovoltaic Energy: Photovoltaic cells capture solar energy and convert it directly to electrical current in a solid-state device. The cells do this by separating electrons from their parent atoms and accelerating them across a one-way electrostatic barrier formed by the junction between two different kinds of semiconductors. Photovoltaic cells are already widely in use on a small scale, as they are built into solar-powered calculators, watches, toys, photosensitive switches, and a variety of other consumer products. Photovoltaic (PV) systems are available today that can provide electricity for residential and commercial buildings. A typical PV system consists of solar cells connected electrically to form a module that can measure two to four feet wide and four to six feet long. Many interconnected PV modules are called an array. An array is often mounted on the roof of a building, or on a tracker, which moves to follow the sun.

Wind Power

Man has used wind power for thousands of years for such mechanical tasks as milling grain and pumping water. However, it is the use of wind energy as a pollution-free means of generating electricity on a significant scale that is peaking current interest in the subject. Wind power is one of the fastest-growing renewable energy technologies worldwide. A total of 31,000 MW wind generating capacity had been installed by the end of 2002. This is about four times the capacity that had been installed by the end of 1997, implying an average growth rate of 40% per annum18.

In the 1980s, the United States was a world leader in wind technology, and California hosted 90 percent of all existing wind power generators. However, poor management, technical flaws, and over dependence on subsidies led to bankruptcy of some major corporations. Currently Danish, German, and Japanese wind machines are capturing the rapidly growing world market.

Wind farms are large concentrations of wind generators producing commercial electricity. Construction sites of wind farms include mountain ridges, plains and seacoasts. Offshore wind farms are being installed by Denmark, the United Kingdom and the Netherlands. These countries expect to soon produce up to 20 percent of their electricity with wind. The World Energy Council predicts that wind could account for 200,000 MW of electricity by 2020, depending on how seriously politicians take global warming and how many uneconomical nuclear reactors go offline. One thousand MW meets the energy needs of about 50,000 typical U.S. households19.

Energy Conservation

Of course, one of the best ways to avoid energy shortages and to relieve environmental and health effects of our current energy technologies is simply to *use less* . The students will research this concept of energy conservation, and see how they can put it to use in their daily lives. Simple concepts for discussion will be cutting down on use of electricity and water, walking and bike riding instead of driving, recycling all possible goods (cans, bottles, newspaper, aluminum foil, cardboard, plastic), and looking into energy-efficient materials for use in the home. The ongoing “mantra” for this closing section of the unit will be Renew/Reuse/Recycle!

Unit Strategies

This unit will be divided into six-eight lessons, to be taught over a three-five week period of time, depending on anticipated additions to the lessons. (NHA students are on a rotating eight-day schedule and do not have Science class every day).

Lesson One: Putting the “Energy Thing” into Perspective /Exploring Model Engines

Main objectives:

1. Students will gain an understanding and appreciation of recent U.S. energy policy, and how it will relate to our discussions of fossil fuels in general.
2. Students will be able to discuss the similarities and differences between the four- stroke and

two-stroke engines, and discuss the advantages and disadvantages of each.

Materials:

Overhead projector, computers with internet access

Procedures:

This lesson will serve as an introduction to the unit, and “set the stage” for the direction of the discussions and activities of the next several weeks.

1. Begin with 10-15 minute lecture/discussion on the energy policy of the U.S. over the last twenty years, and how it relates to current events today (e.g. the war in Iraq, price of gasoline). See “Historical Perspective” for a guide.
2. Introduce the idea that we are going to begin the unit by looking at two very common engines, the four-stroke and the two-stroke, and gain a basic understanding of how they utilize fuel.
3. Follow with a brief discussion of the components of the four-stroke cycle: intake, compression, power, and exhaust.
4. Access the web site http://www.keveney.com/otto.html together as a class, and watch the engines in motion. If this is not possible due to technical limitations, have handouts ready from web site to distribute and discuss.

Assessment:

Students will be given a homework worksheet with matching and fill-in the blank questions regarding the class discussion.

Lesson Two: Further Investigation of Internal Combustion Engines

Main objectives:

1. Students will be able to locate and identify the major moving parts of an internal combustion engine, and discuss the functions thereof.
2. Students will be able to discuss how fuel is used in an internal combustion engine.

Materials:

Four-stroke engine block, examples of a two-stroke engine (chainsaw, weedwacker, model airplane), computers with internet access and/or research materials on fuel efficiency.

Procedures:

The execution of this lesson will largely depend on space and equipment availability.

1. If possible, arrange for an area to set up an actual engine block of a car or truck (four stroke engine), and have several examples of two stroke engines available (e.g. chainsaw, model airplane, weedwacker).
2. Divide students into groups; assign each group to a piece of equipment.
3. Have students locate and identify working parts of individual motors, and trace path of fuel.
4. Back in the classroom, have student groups do research on different models and makes of car engines and the associated fuel efficiency. Assign each group a four, six, and eight cylinder vehicle to research.

If the above procedure is not feasible, try to investigate a trip to a local vocational school or machine shop where the students might have similar opportunities to view actual engines.

Assessment:

Students will complete a matching exercise with a schematic of a four-stroke engine, and its major parts. For homework, students will document the results of their fuel efficiency research, and write a short essay discussing their findings.

Lesson Three: Fossil Fuel Formation and Current Locations

Main objectives:

1. Students will be able to compare/contrast three different fossil fuels: coal, natural gas, and oil.
2. Students will be able to identify and discuss the major geographic locations of fossil fuel deposits.

Materials:

Questionnaire, overhead projector, world map, colored pencils

Procedures:

1. Begin the lesson with a k-w-l exercise or use the questionnaire included in Appendix A (Figure 1) to gain understanding of student knowledge of/interest in fossil fuels.
2. Collect and discuss questionnaire. Use questions to create a vocabulary list; from this create a word wall.
3. Follow with a 15-20 minute lecture/discussion on the formation of fossil fuels, and current locations thereof in the world today. Emphasize *nonrenewable* nature of the fuels. Distribute a fact sheet with information on location of fossil fuels.
4. Break class into three groups: coal group, oil group, and natural gas group. Distribute a world map, and have students locate geographical locations of their assigned fuel and color-code. Use Figure 2 (from Appendix A) to record findings.

Assessment:

The color-coded world map and completed Figure 2 will be the group assessment.

Lesson Four: Fossil Fuel Discovery, Attainment, Processing and Usage

Main objectives:

1. Students will be able to discuss the different methods of discovery and attainment (e.g. mining, drilling) of the fossil fuels
2. Students will be able to discuss processing methods of fossil fuels
3. Students will be able to discuss present-day usage of fossil fuels

Materials:

World map, textbook, overhead projector

Procedures:

1. Begin with review of previous lesson, highlighting the physical location of the fossil fuels worldwide.
2. Follow with 30-40 minute lecture on discovery/recovery, processing and usage of each fuel.
3. Again split class into two groups: the coal group and the oil/natural gas group. Have students pretend that they are either a coal mining company or a petroleum & natural gas recovery company. Using notes from class, and any additional resources (textbook, previous maps and handouts), have the groups use Figure 3 (Appendix A) to prepare questions to be presented to the class. Have the groups present findings to the class, in the form of a professional presentation

(as if marketing to a consumer)

Assessment:

The group presentation will be the assessment tool. Groups will be rated on research methods, organization, content, format and delivery of their presentation.

Lesson Five: Investigating the Impact of Fossil Fuel Usage on the Environment and Finding Possible Solutions for the Reduction Thereof

Main objectives:

1. Students will be able to identify short- and long-term impacts of fossil fuel usage on the environment (especially air pollution, acid rain and global warming).
2. Students will be able to identify possible solutions for reduction of negative impacts by fossil fuels on the environment, and relate these options to their day-to-day lives.

Materials:

Overhead projector, conservation checklist

Procedures:

1. Begin with a lecture/discussion of the gases produced by burning fossil fuels [CO2, CH4, sulfur oxides, nitrogen oxides, and chlorofluorocarbons, (CFCs)]. Define and explain acid rain and global warming. Discuss why the above gases are called "greenhouse gases".
2. Define energy conservation. Discuss how conserving energy can reduce global warming.
3. Break students into three groups. Have each group identify ways in which they can conserve energy at home, at school, and in the community, and record. Students must be prepared to explain why a certain action conserves energy.
4. Have groups share ideas and discuss in a "round robin" format.

Assessment:

Each group will submit their results, which will be assessed. As a homework assignment, each student will choose three of the conservation efforts discussed either in their group or during the class discussion, and complete a checklist as to how they will apply these efforts at home and in their neighborhood/community.

Lesson Six: Exploring Renewable Alternative Energy Sources: Solar Energy

Main objectives:

1. Students will be able to identify and discuss viable alternative energy sources for the near future.
2. Students will be able to discuss the different aspects of solar energy
3. Students will construct a solar energy project

Materials:

Aluminum foil, poster board, unpainted wire coat hanger, cellophane or masking tape, two cardboard boxes, two nuts, two bolts.

Procedures:

1. Begin with a 10-15 minute lecture/discussion on the renewable alternative energy systems: solar and nuclear power, hydroelectric power, biomass energy, wind energy and fuel cells.
2. Explain that for this lesson we will focus on solar energy. Follow with a 15-minute lecture on solar energy: passive, active and photovoltaic.
3. Introduce solar hot dog cooker project. (See Figure 4, Appendix A)
4. Have students work in groups of 3-4 on the project.

Assessment:

Each group will conduct the experiment, and write a report in the scientific method format. Execution of the experiment and the report will be the assessment tools.

Lesson Seven: Exploring Renewable Alternative Energy Sources: Wind Energy

Main objectives:

1. Students will be able to discuss the different aspects of wind energy
2. Students will construct a wind energy project

Materials:

Pencil, pin, two soda straws, stapler, scissors, cone pattern, paper, tape, bottle with narrow neck, and stopwatch

Procedures:

1. Begin by reviewing briefly the previous discussions on renewable alternative energy sources.
2. Explain that for this lesson we will focus on wind energy. Follow with a 15-minute lecture on available wind energy technologies.
3. Introduce wind speed project (See Figure 5, Appendix A).
4. Have students work in groups of 3-4 on the project.

Assessment:

Each group will conduct the experiment, and write a report in the scientific method format. Execution of the experiment and the report will be the assessment tools.

Resources

Teacher Resources

1. Alters, Sandra, Energy: Shortage, Glut or Enough? Information Plus Reference Series, 2003. Good basic overview of the energy situation.

2. Arms, Karen, *Environmental Science,* Holt, Reinhart and Winston, 1999. Standard textbook used in New Haven.

3. Blatt, Harvey, Our Geologic Environment, Prentice Hall, Inc., 1997. Textbook used at SCSU for an introductory Earth Science class. Great resource.

4. Boyle, Godfrey, Renewable Energy: Power for a Sustainable Future, Second Edition, 2004, Oxford University Press, New York. A textbook written as a major component of the Open University's second level undergraduate course *T206 Energy for a Sustainable Future.* Written from the British point of view. Very informative and readable.

5. Chandler, Gary, *Alternative Energy Sources,* Millbrook Press, 1996. Part of a book series ("Making a Better World"), a good starting point for alternative forms of energy. Short and easy to read.

6. Cunningham, William, Principles of Environmental Science: Inquiry and Applications, Second Edition, 2004. McGraw-Hill Companies, Inc. Textbook used at SCSU for an introductory Earth Science class. Great resource.

7. Fay, James A., and Dan S. Golomb, Energy and the Environment, 2002, Oxford University Press, New York. Chapters of this book were distributed by Dr. Gomez in the seminar. Informative and well organized.

8. Fenn, J. B. *Engines, Energy and Entropy,* W. H. Freeman Co., New York, 1982

Distributed by Dr. Gomez in the seminar, a very readable thermodynamics text.

9. Grolier Library of Environmental Concepts and Issues, *Using Earth's Resources,* Grolier Publishing Company, 1992. Informative, concise text. Offers "Envirobits" (thumbnail facts on the environment) throughout.

10. Hayhurst, Chris, *Hydrogen Power of the Future: New Ways of Turning Fuel Cells Into Energy,* Rosen Publishing, 2003. From the Library of Future Energy, concise and readable. Offers a good, brief discussion on the politics of energy.

11. New Haven Science Teachers' Curriculum Development Team, *Content Standards and Expected Performances for High School Science Grades 9-12* , November, 2003.

12. Pack, Janet, *Fueling the Future,* B&B Publishing, 1992. Good source for fossil fuel and alternative energy information. Nice photos and suggestions for follow-up activities with organizations.

13. Pipkin, Bernard, Geology and the Environment, Fourth Edition, 2005. Thompson Learning, Inc. Textbook used at SCSU for an introductory Earth Science class. Great resource.

14. Roth, Alfred C., Small Gas Engines, Goodheart-Willcox Co., 2000. Used as a text in technical schools, a good primer on engines, complete with activities and quizzes.

15. Wysession, Michael, David Frank and Sophia Yancopoulos, Physical Science: Concepts in Action, Prentice Hall, 2004. High school text selected for NHA students. Good graphics and activities.

Student Resources

1. Alters, Sandra, Energy: Shortage, Glut or Enough? Information Plus Reference Series, 2003. Good basic overview of the energy situation.

2. Gardner, Robert, *Science Projects About the Environment and Ecology,* Enslow Publishers, 1999. Discusses the environment in relationship to ecology, global cycles, humans, population trends, and energy. Each section offers hands-on activities, many specifically suited to science fair entries. Written in handbook form, it is very concise and readable.

3. Grolier Library of Environmental Concepts and Issues, *Using Earth's Resources,* Grolier Publishing Company, 1992. Informative, concise text. Offers "Envirobits" (thumbnail facts on the environment) throughout.

4. Langholz, Jeffrey, and Kelly Turner, You Can Prevent Global Warming, Andrews McMeel Publishing, Kansas City, 2003. Written in handbook form, a light-hearted guide to 51 ways to help reduce global warming (and save money) on a daily basis.

5. Olney, Ross, *The Internal Combustion Engine,* J.B. Lippincott, 1982

This is a delightful "primer" on the internal combustion engine, complete with hand-drawn graphics.

6. Roa, Michael, *Environmental Science Activities Kit,* The Center for Applied Research in Education, 1993. A good source for science fair ideas.

7. Roth, Alfred C., Small Gas Engines, Goodheart-Willcox Co., 2000. Used as a text in technical schools, a good primer on engines, complete with activities and quizzes.

General Websites

1. http://. Good information on global warming, and a plethora of general environmental information.

2. http://. Great curriculum information, grant suggestions, workshop and conference info.

3. http://. EPA's website for kids. Good links called "Science Room" and "Ask EPA"

4. http://. On-line version of World Book Encyclopedia, complete with atlas, dictionary, and a history section entitled "Back in Time"

5. http://science.howstuffworks.com Great source for information on engines

6. http://climatechange.unep.net/. Information on federal Fossil Energy Programs

7. http://www.energy.gov/engine/content.do?. Science Education Initiative of the Department of Energy

8. http://. Statewide information on environmental quality and pollution prevention

9. http://. Good source for auto emission information

10. http://. Information on energy sources, fossil fuels and global warming

Internal Combustion Engine Websites

1. http://auto.howstuffworks.com/engine.htm. Fantastic animated site, with tons of usable information on engines.

2. http://www.siu.edu/~autoclub/frange.html. An actual condensed lesson plan, entitled "Back to Basics: Fundamentals of the Four Stroke Internal Combustion Engine." Presented by the Automotive Technology Organization at Southern Illinois University:

3. http://school.discovery.com/lessonplans/programs/energyandcars. The Discovery Channel's Energy and Cars site, provides a complete lesson plan, adaptable to many grade levels.

4. . Matt Keveney's personal web page. Shows animated illustrations of a variety of working engines

Alternative Fuels Websites

1. http://www.methanol.org/. A good source for information on methanol-fueled cars, maintained by the Methanol Institute.

2. http://www.electricdrive.org/. A site maintained by the Electric Drive Transportation Association, provided a comparison of electric drove provisions included in the House and Senate Highway Reauthorization Bills of 2004.

3. http://www.nfcrc.uci.edu/. A site maintained by the National Fuel Cell Research Center (University of California at Irvine), provides information on systems, operation, and analyses of fuel cell technology.

4. http://www.fuelcells.org/. Offered by Fuel Cells 2000, this site is dubbed the "On-line fuel cell information resource." Provides animated demos of an operating fuel cell.

5. http://www.hydrogen.org/index-e.html. The Hydrogen and Fuel Cell Information System (HyWeb) website. Provides information on alternative transportation technology, including a newsletter.

6. http://www.hydrogenus.com/. Offered by the National Hydrogen Association, this site covers a host of issues related to hydrogen energy systems. Provides access to two periodicals.

7. http://www.ford.com/en/innovation/engineFuelTechnology/default.htm.. The Ford Motor Company Engine and Fuel Technology website. Provides a technology report and updated on research and development of electric- and hydrogen-powered vehicles.

8. http://www.eere.energy.gov/. The U.S. Dept. of Energy's Energy Efficiency and Renewable Energy portal, a "gateway to hundreds of websites and thousands of online documents on energy efficiency and renewable energy."

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Appendix A

Fossil Fuel Questionnaire

1. What do we mean by “fossil fuel?”

2. Name one (or more) fossil fuel.

3. How are fossil fuels formed? How long does it take?

4. Where are fossil fuels located worldwide?

5. What are fossil fuels used for?

6. What is meant by “renewable” and “nonrenewable in reference to energy sources?

Figure 1: Fossil Fuel Questionnaire

Location of Fossil Fuels Worldwide

COAL:

PETROLEUM:

NATURAL GAS:

Figure 2: Location of Fossil Fuels Worldwide

FOSSIL FUEL MARKETING EXERCISE

Where will I look for the fuel?

What discovery methods will I use?

How will I extract the fuel from its location?

What processing methods will be necessary?

How/for what will my fuel be used?

Who will be my target market?

Figure 3: Fossil fuel marketing exercise.

How to construct a parabolic solar hot dog cooker

You can find poster board at art supply stores, and nuts and bolts at a hardware store. You can generally get old boxes from a grocery store.

Materials for each hot dog cooker:

A 14-inch sheet of aluminum foil, an 11x14-inch piece of poster board, a wire coat hanger, tape, two shoe boxes (one for the collector and one for a stand), a hot dog, and two nuts and two bolts.

1. Make the ends of the parabolic trough out of the cardboard using the pattern shown here. (You will need to enlarge the pattern to match the scale given.)

2. Tape the aluminum foil to the piece of poster board.

3. Curve the poster board and tape it to the two curved ends.

4. Attach the trough to the box frame using nuts and bolts. Make sure the trough can move up and down but will stay in one place.

5. Put holes at either end of the trough focal point.

6. Straighten the wire coat hanger and bend one end to make a handle.

7. Push the coat hanger through the hole on one side. Put the hot dog on the coat hanger, and push the coat hanger through the hole on the other side.

8. Place the solar cooker so the mirrored trough faces the sun.

9. Adjust the trough up and down until the mirrored surface focuses the sun on the hotdog.

10. Cook the hot dog.

What did you see?

How long did it take to cook the hot dog?

Did you have to move the cooker to keep the sun focused on the hotdog?

How parabolic collector works:

A parabolic collector is made up of a trough and a tube running down the center of the trough. The trough is a long rectangular mirror formed in a U-shape. The mirror is tilted toward the sun to focus the sunlight on the tube. The paraboloid shape is perfect for focusing the sunlight on the tube. The tube carries the fluid to be heated. A tracking device keeps the mirrors pointed toward the sun as it moves across the sky.

Parabolic collectors are used mostly to provide hot water for use in industry and sometimes in homes. They are also used to produce electricity.

Figure 4: Solar hot dog cooker (Source: http://www.energyquest.ca.gov/transportation/ index.html)

(image available in print form)

How can you measure wind energy?

Some places have a lot of wind and others don't. For example, places that are higher or more open usually have stronger winds. Before you bought or built a windmill, you would want to be sure that your location had enough wind. But how can you measure the wind?

An anemometer is used to measure wind energy. You sometimes see them at airports. You are going to make a simple anemometer and measure the wind energy around your school.

Materials for each anemometer:

Pencil, pin, two soda straws, staplers, scissors, cone pattern, paper, tape, bottle with narrow neck, and stopwatch.

Steps [see Figure 5 (Con't)]

1. Staple the two straws together to make an X. Reinforce with tape.

2. Cut out patterns (~5" circle with a 100º wedge cut out) for the four cones. Color one of these red.

3. Staple one cone pattern to the end of each straw, so that they all face in the same direction.

4. Curve and tape each cone pattern to form a cone.

5. Using a pin or thin nail, pin the center of the X to the pencil eraser.

6. Insert the pencil in a narrow-neck bottle and the anemometer will spin freely.

Measuring Wind Speed

This anemometer cannot not tell the wind speed [in miles per hour for example, unless you calibrate it using known wind speed (e.g. using a scientific anemometer)], but it can give you a relative idea of how fast the wind is blowing around your school.

Using a stopwatch, count the number of times the colored cone spins around in one minute. You are measuring the wind speed in revolutions (turns) per minute. Weather forecasters' anemometers convert the revolutions per minute into miles per hour (or kilometers per hour). Keep a record of the wind speeds you're measuring for the next few days.

Measure the wind speed at different times of the day. Is it the same in the morning; the afternoon; the evening? Move your anemometer to another location. Is it windier in other places? Do trees or buildings block the wind?

FIGURE 5: Wind speed project (source: http://www.nrel.gov and http://www.energyquest.ca.gov/projects/anemometer.html).

(image available in print form)