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Energy Quest: Exploring Sun, Wind, and Water

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Rationale and Overview

The rationale behind the unit is that it is vital to our global future to provide energy education to children. Energy will continue to play an increasing role in politics, the economy, our environment and in human health. The hope is that energy education will help students become concerned energy citizens, well educated consumers of energy, and possibly spark an interest in playing a role in the energy industry of the future. It has become increasingly clear that it is necessary to change our attitudes and behaviors surrounding energy consumption. Early education in energy helps promote this goal of change. I have chosen to focus this curriculum unit on renewable resources because of my belief that increasing our usage of renewable energy resources as well as developing and improving technologies associated with these sources will play an important role in the global energy profile in upcoming decades. I believe that students can learn to make informed energy choices and that this learning should be an active and dynamic process for students.

The unit is designed to target 4 th and 5 th grade students. The first part of the unit will begin by exploring the most basic concepts of what energy is. The learning will then transition into exploring different energy sources and an investigation of how use of renewable and non-renewable resources impact climate and the environment. In the second part of the unit, the two grade levels will diverge and begin a focused study of their particular energy source(s). 4 th grade students will examine solar energy while the 5 th grade students will look at the energy sources of wind and water. The overall goal of the ENERGY QUEST unit is to engage students in exciting and authentic hands-on learning in science and to give them the information necessary to help change the future of energy in this country.

Background Information

The Demand for Energy

One of the great challenges facing humanity is how to be responsible stewards of the natural resources entrusted to them. A growing worldwide population and increasing energy demand is exerting greater strain on our environment and on fiscal and natural resources. As individuals and as a society, we must be prepared to deal with the problems that will challenge us in the decades ahead. It is my hope that early education focusing on sustainability and alternative technologies will provide one piece of the solution to this challenge.

Much of our current standards of living were built on the back of increasing demands for energy. At a time in not too distant human history, human energy demands consisted of providing for the basic needs of food and warmth. Residents of modern industrial societies use far more energy than their own bodies can produce- about one hundred times as much in North America and twenty times as much averaged over the globe. [1] This trend shows no sign of stopping, and the Energy Information Agency (the statistical arm of the U.S. Energy Department) predicts that global energy demand will grow by 50 percent over the next two decades with continued heavy reliance on fossil fuels.

Political and Economic Implications of Fossil Fuel Dependency

Fossil fuels (coal, oil, and natural gas) provide 80 percent of the globe's energy needs. Some studies have estimated that it will take just a little over 30 years to consume the remainder of the proven worldwide reserves of oil and natural gas liquids. The relative scarcity of this non-renewable resource will continue to intensify political and economic pressures surrounding this commodity. In the U.S. this issue is compounded by the fact we currently rely on foreign imports to provide 60% of our demand for oil which is over a 33% increase just since 1990. [2] (See figure 1.0) As of 2006, OPEC (Organization of the Petroleum Exporting Countries) member countries held over 76% of the world's known oil reserves. [3] (See figure 1.1) The twelve current member countries of OPEC are Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela. The long term reliability of dependence on foreign oil is further threatened by the fact that many of the regions that supply most of the U.S. imports have long histories of political instability. As Americans, we cannot simply assume that we play the role of innocent bystander in this political instability, but rather function as an active participant in these world events. American economist and former chairman of the United States Federal Reserve Board, Alan Greenspan, clearly states his opinion of the 2003 invasion of Iraq by the United States. "I am saddened that it is politically inconvenient to acknowledge what everyone knows: the Iraq war is largely about oil," he says. [4]

In terms of economic impacts, the fluctuations in energy prices have never been greater, reaching record highs in 2008 and then plunging rapidly again in early 2009. The economic impacts of energy prices cannot be examined through the narrow lens of the prices paid at the pump or a consumer's monthly utility bill, but rather as a key part in the overall health of the national economy. Businesses make investment decisions based upon expectations of energy prices and volatility in those prices can cause them to make inappropriate business decisions. Economists agree that inflation tracks movements in world oil prices and that high energy prices can become a drag on the overall economy. [5] (See figure 2.0).

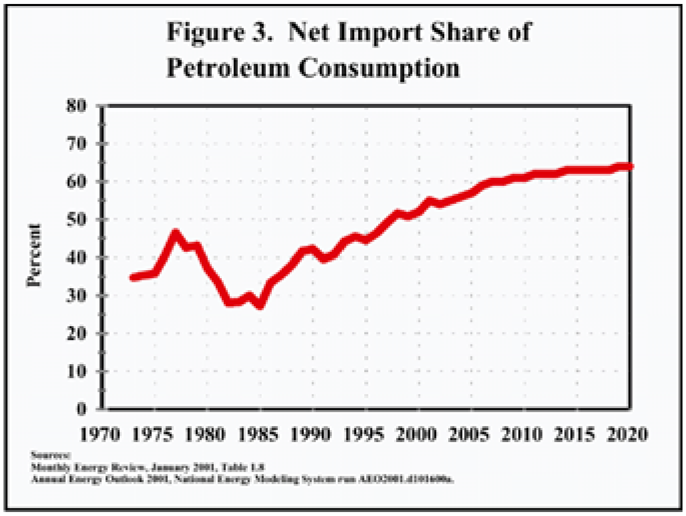

Figure 1.0 [6]

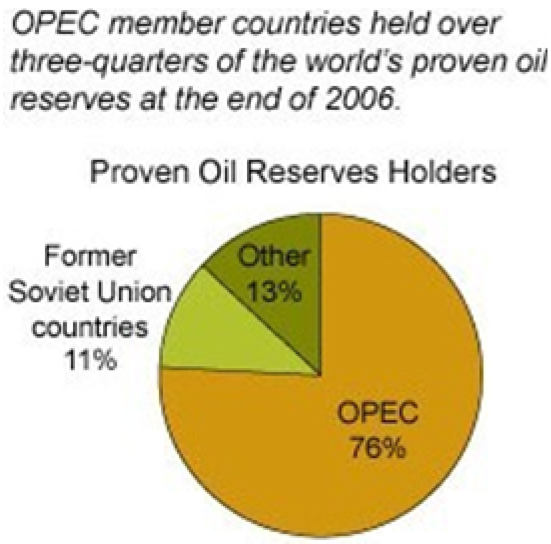

Figure 1.1 [7]

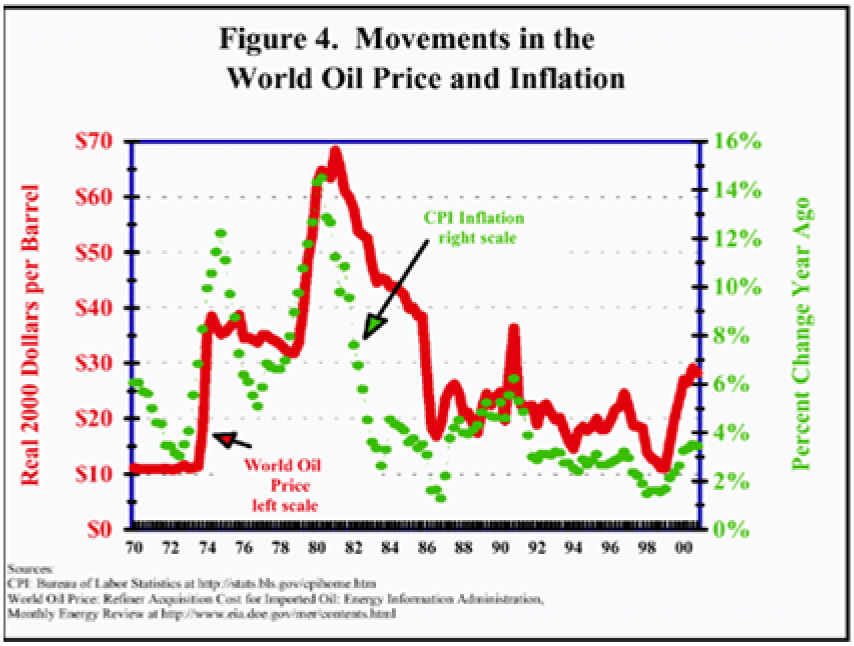

Figure 2.0 [8]

Fossil Fuels and Climate, Environment, and Human Health

The fact that we are running out of fossil fuels and the political and economic tensions associated with the shortage is only one side of the issue; the other is the impact that their use is having on the environment, climate, and human health. There are two main types of products generated during the process of burning fossil fuels that have significant environmental impacts: carbon dioxide and pollutants. To examine the two categories it is first vital to understand that the release of stored energy in fossil fuels is due to the combustion of hydrocarbon chains. The production of carbon dioxide is essential to the process of combustion as the fuel's carbon and hydrogen are combined with atmospheric oxygen, which leads to the release of carbon dioxide, water, and thermal (heat) energy. Essentially, there is no way to avoid carbon dioxide production in the burning of fossil fuels because it is an essential by-product of the chemical reaction of combustion of hydrocarbons. Secondly, there are traditional pollutants, which are harmful and inessential by-products that do not arise directly from combustion of the hydrocarbon chain, but rather arise from substances other than carbon and hydrogen that can be found in fossil fuels. Some of the many possible pollutants released include carbon monoxide, nitrogen oxides, mercury and sulfur, as well as particulate matter (tiny solid particles that do not burn during combustion and are carried along with the stream of gases).

Air Pollutants

Air pollutants have a whole host of harmful environmental and health impacts. Carbon monoxide (CO) is a bi-product resulting from incomplete combustion of fossil fuels and other materials containing carbon, such as wood or charcoal. The main health effect is a result of CO's affinity for hemoglobin, which is the molecule found in red blood cells that carries oxygen throughout the body. CO binds 240 times more readily to hemoglobin than oxygen and once bound is very difficult to displace. [9] Therefore, exposure to elevated levels of CO reduces the blood's oxygen carrying abilities; this is no truer than for smokers whose carboxyhemoglobin levels are already an average of 4 times what they are for non-smokers. Because CO emissions are more easily controlled at stationary sources such as power plants, 2/3 of all CO emissions come directly from vehicles. CO emission is reduced by the use of a catalytic converter and CO is one of the main gases that are being checked for when a vehicle is taken in for a vehicle emissions test.

Other pollutants that would be checked for during a vehicle emissions test is the variety of compounds called nitrogen oxides (NO_x), however, the responsibility for production of NO_x is shared more evenly among transportation, industry, and electrical power plants. Not only do nitrogen oxides give air a dirty brown appearance but prolonged exposure can also result in lung damage. In addition, sunlight can cause further chemical reactions within the atmosphere converting nitrogen dioxide (NO_2 is one of the members of the NO_x group) to ozone (O_3). At first this may seem like a desirable affect since we know that ozone gas in the stratosphere protects the Earth's surface from harmful ultra-violet rays, but ozone in the lower atmosphere is actually harmful to health. Ozone is a highly reactive chemical and can trigger a whole host of other reactions in the atmosphere leading to still further generation of harmful substances. The end results can lead to eye irritation and respiratory problems in humans, as well as damage to plants and surface materials such as paints and fabrics.

The burning of fossil fuels also releases a variety of heavy metal pollutants including lead and mercury. Mercury is the widest spread heavy metal contaminant and the dominant source of mercury pollution is from coal-burning power plants. Mercury pollution contaminates surface waters of the earth and ends up in the food chain and concentrates as it works its way up to high level predators (bioaccumulation). The fish in the U.S. are so "poisoned" that pregnant women are often advised to not eat certain species of freshwater fish. In the nation's largest hair sampling test of mercury contamination in humans, published by the Environmental Quality Institute at the University of North Carolina-Ashville, it was found that 1/5 of all women of child bearing age have levels of mercury exceeding the EPA recommendation of 1 part per million (in hair). More than 6,600 women from 50 states of all ages participated in the hair tests conducted by Greenpeace and the Sierra Club and in some states the percentage of participants testing above recommended mercury levels was as high as 40%. (See figure 3.0) [10]

Another form of air pollution results from the release of sulfur dioxide (SO_2) into the atmosphere predominantly from the burning of coal. SO_2 itself is detrimental to human health. In 1952, when the atmospheric levels of SO_2 rose sevenfold in London, England it resulted in the deaths of some four thousand people. [11] This is not, however, the end of the story for sulfur pollution. Once in the atmosphere, sulfur dioxide undergoes a series of chemical reactions which eventually generates sulfuric acid (H_2SO_4) resulting in what we know as acid rain. Acid rain is responsible for affecting water quality, damaging vegetation, and causing increased corrosion of buildings and many other surface materials.

One other form of air pollution related to the burning of fossil fuels is the release of particulate matter. Particulate pollution is associated with the burning of coal and of heavier liquid fuels like diesel oil. Particulate pollution is quite visible, and if you have ever seen a large semi-truck starting up and billowing large clouds of black smoke then you have seen particulate pollution. Breathing particulate laden air can result in numerous respiratory ailments such as emphysema, chronic bronchitis, and asthma. The technologies for reducing particulate pollution are readily available and widespread in use. Long gone is the dark black smoke that used to constantly loom over industrialized areas of the U.S. during the 19th century. However, it is the smaller, less visible particles that are of the greatest concern. Particles less than 10 microns in size can reach deep into the lungs, are not then easily expelled, and therefore can cause the most damage. A study performed by the Clean Air Task Force in 2004 suggested that as many as 24,000 premature deaths per year in the United States may be the result of particulate air pollution. [12] Unfortunately, as gruesome as the realities are associated with the above mentioned forms of air pollution, traditional pollution has become the least of the problems associated with fossil fuels.

Figure 3.0 [13] Results for States with at Least 100 Participants

STATE	# of Participants	Median Mercury (ug/g)	Percent > 1.0 ug/g	Median Total Seafood Servings per month
CA	1090	0.62	30.0	5.0
CO	135	0.67	30.4	5.0
FL	389	0.61	33.4	6.0
IL	169	0.31	15.4	5.0
MA	218	0.61	27.1	5.0
MD	218	0.48	17.4	4.0
MI	115	0.38	20.9	4.0
MN	293	0.24	8.9	4.0
NC	175	0.41	15.4	4.0
NH	133	0.46	18.8	6.0
NJ	192	0.48	27.1	5.0
NY	455	0.76	40.2	5.5
OH	415	0.22	10.6	4.0
OR	130	0.62	26.2	6.0
PA	535	0.26	11.4	3.0
TX	203	0.38	15.8	5.0
UT	139	0.36	15.1	5.0
VA	149	0.40	27.5	5.0
WA	184	0.57	28.8	6.0
WI	126	0.22	10.3	4.0

Carbon Dioxide and Climate Change

In this decade, consequences associated with tradition pollution have now been overshadowed by the concern about global climate change. Up until the mid-twentieth century, solar variability and volcanic activity accounted for the majority of climate variation. In recent decades, data has shown a rapid warming trend. Only by looking towards anthropogenic caused or produced by humans) agents can climate scientists account for the warming of the late 20th and early 21st century. According to the Intergovernmental Panel on Climate Change (IPCC) 2007 Synthesis Report on Climate Change, most of the global warming over the past 50 years is due to anthropogenic "greenhouse gasses". [14] Carbon dioxide (CO_2) emissions from the burning of fossil fuels are the main culprit behind global warming. As carbon dioxide collects in the atmosphere, this gas absorbs and emits thermal radiation. With increased amounts of atmospheric carbon dioxide, the result is increased heat trapped within the earth's atmosphere; leading to a "greenhouse" like effect. Unfortunately, this particular "greenhouse gas" has an atmospheric lifespan of between 50-200 years, meaning that it will stay in Earth's atmosphere for at least 50 years. Consequently, carbon dioxide emitted today could continue to contribute to global warming for up to two centuries to come. This problem is exacerbated by the fact that carbon dioxide output is not stagnant, but rather growing at an alarming rate. The Energy Information Administration claims that without mandatory actions to address global warming, the amount of CO_2 flowing into the atmosphere each year from energy use will be 51 percent greater in 2030 than it was in 2005. [15]

The global impacts of this warming are numerous and widespread. Continued melting of polar snow and ice pack and thermal expansion of the oceans will contribute to rising global sea level. Currently, half of the human population lives in coastal areas-some in areas that are already below sea level. The projected sea level rise will flood a great deal of developed land directly while submitting many millions of other people to yearly flooding. A side effect of this rise in sea level is salt water intrusion into freshwater resources, making that commodity increasingly scarce. Large-scale ocean circulation changes are also likely with increased global warming. Ocean currents play a major role in determining local climate, and ironically global warming could bring about deep freezes in once temperate locals. Because every species of organism has a natural range of climactic conditions they can tolerate, there is an expected change in geographic range of species associated with global warming. As the Earth warms, species are expected to shift towards the poles and higher elevations. Although a simple "shift" seems innocuous at first, the reality is that it will lead to a more compressed species-area relationship thereby contributing to an eventual loss of biodiversity as the area can no longer support the increased number and variety of organisms inhabiting it. Increased frequency and severity of extreme weather events are almost certain in the wake of a rise in global temperature. Ocean acidification is another consequence of increased CO_2 in the atmosphere. Under such acidic conditions, certain types of plankton that form the base of marine food chains may have difficulty surviving. These reflect only some of the global climate changes that mankind will be faced with.

Projections of how fast global warming will occur and how severe the resulting consequences, are largely dependent on assumptions about human behavior. Scientists have projected a wide range of possible models based on changes in human energy consumption, reduced reliance on fossil fuels, as well as technologies to mitigate the effects of atmospheric CO_2 such as carbon offsets and carbon sequestration. One thing is certain: with current practices and behaviors surrounding energy usage, global greenhouse gas emissions will continue to grow over the next few decades; driving global warming. The fallout of global warming will not be equally distributed, however, and some of the world's regions with the smallest carbon footprint will get the brunt of the blow. The IPCC 2007 Synthesis Report on Climate Change cites the Arctic, Africa, small islands and Asian and African megadeltas as being some of the world's most vulnerable regions. [16] This compounds the dilemma by raising serious ethical issues about one group of people "paying the bill" environmentally for another group's energy consumption.

Objectives and Strategies

All 4th and 5th grade students will gain knowledge about and experience with energy during a ten week intensive energy project. The majority of activities will take place during a once per week 40 minute block of Science Lab, however, additional reinforcement of activities will take place within the self-contained classrooms. The first four weeks will focus on an energy overview for all students. Over the course of the four weeks following, 4th graders will explore energy from the sun and 5th graders will examine energy from wind and water. Finally, the final two weeks will be spent in culminating activities where students demonstrate and share the new knowledge that they have gained. The overarching objectives for the entire curriculum unit are for students to understand: 1) what energy is 2) where does energy come from (energy sources) 3) how energy usage affects climate, environment, and human health and 4) how to make informed energy choices.

Energy Overview for All Students

One of the first objectives of the curriculum unit is for all students to gain a fundamental and concrete understanding of what energy is. Energy can sometimes be difficult for younger students to understand because it is a more abstract and less tangible scientific concept. The strategy that I intend to use to help make energy easier to grasp is to have students engage in an activity where they rotate among stations that will contain hands-on demonstrations of different types of energy. Students will not be given any prior information or formalized definition of what energy is prior to participation in the activity. I feel that this strategy is effective in getting students to think critically about what is going on in each center and how it might relate somehow to energy. At each station students will answer one simple question: Based on what you did in station #___, what do you think energy is? I have noticed at different points at time that my own students are overly eager for me to simply give them the "right answer" without trying to really stretch their own powers of observation and reason. I believe that this type of constructivist (where students construct their own knowledge) approach helps to counter that idea of what it means to learn something. Not only that, but as students rotate throughout the centers they are forced to activate their own prior knowledge to make connection with the material, therefore the new information becomes a natural part of their own internal schema.

A second objective for the unit is for students to acquire a body of factual information about the ten major sources of energy, including the impact that they have on the environment, climate, and human health. The strategy that I will use to accomplish this is a jigsaw activity. A jigsaw activity is a cooperative learning technique where-just as in a jigsaw puzzle-each student will hold an essential part-to the cooperative group having a complete and full picture of the material. I have noticed that one obstacle of truly successful cooperative groups is that some students want to control all of the tasks and others don't want to complete any of the tasks. If each student's role is essential to group success then each student themselves become essential to the learning process. In each group, one student will research and become the expert on his/her energy source. I have noticed in my own classroom that when students know that they are going to have to "teach" other students the material, they usually gain a deeper understanding of the information themselves and that is why I have chosen this particular strategy. Prior to coming back to the group, the students will meet as a panel of "experts", for example: all people with the energy source of "oil" will conference and share information. This strategy allows learning to become a synergistic process and reinforces the idea that there is not just one "right answer", but rather many. When groups reconvene, each group member will be creating sets of energy fact cards. The strategy employed here is that students are creating a reference resource for themselves that they can refer to throughout the unit when memory of a particular energy source becomes cloudy. Rather than relying on the teacher to refresh the body of knowledge or simply stumbling along without understanding, students become self-reliant knowing that they have a place to go to when they need information.

Finally, this new body of knowledge will be put to the test with a super fun informal assessment activity disguised as a game. Teams are assigned particular energy source and the goal is to keep your energy a source a secret while figuring out which energy source other teams have. The reason that I have chosen this game is that the more times the game is played, the more strongly the information is reinforced. When students have something to directly gain from acquiring the information, even if it is only bragging rights over another team, suddenly that body of information has intrinsic real world value to them in the present.

A third objective for both 4 th and 5 th grade students is to practice making real world energy choices. To accomplish this goal, I have decided to utilize the strategy of using case studies. From the prior activity, students may have a theoretical understanding of why choosing one source of energy is preferable to another. I believe that at this point in their understanding, some students may wonder why we are not just abandoning fossil fuels use all together. However, it is often the case that real world choices are not that simple and provide dilemmas that require setting priorities, weighing pros and cons, and making decisions when a best choice in not immediately evident. I hope that this strategy will give students a glimpse into how complex the world of energy choices really is as well as give them practical experience in using decision making skills. Many students have the misconception that energy choices are something relegated to the world of adulthood, so another strength of this strategy is to get students thinking reflectively about their own day to day energy choices. To help scaffold students (provide a temporary framework to support the construction of learning) through the decision making process, we will utilize a "decision tree" which is a tree-like model of decisions and their possible outcomes and consequences.

A final objective for both grade levels, before they diverge into an in depth look at their own particular energy source is for students to gain a basic understanding of how electricity is generated. This is a vital piece to the continuum of understanding because the three forms of renewable resources that are being studied (sun, wind, and water) are going to be examined primarily from their potential to be sources of generating electricity. I have discovered among my own students, and indeed many adults, that there is no real sense of how the electricity coming from the switches and outlets we are so familiar with is actually produced. My initial strategy is to start the lesson with a look at an electromagnet. I have chosen this specifically because building an electromagnet is a favorite science fair project among my 4 th and 5 th grade students already; therefore they have some prior background knowledge. I want to explore the idea of whether or not they can make the leap from using electricity (in the form of a battery) to generate a magnetic field to the ability to run the process in reverse using a magnetic field to generate a current of electricity.

The second portion is to have students watch a teacher led demonstration of the basic components of a small motor and how it can be converted to a generator using a hand crank. I felt that because my student body is still relatively young, a teacher led demonstration would be best suited for this step rather than a hands-on activity. Students will still get to see a tangible example while reducing the potential for student injury from the mild shock potential in this experiment. A secondary objective is for students to walk away with the knowledge that no matter what the energy source used (coal, sun, water, etc.); electricity is still made in the same way by spinning a magnet within a coil of wire or spinning a coil of wire around a magnet. To accomplish this goal, I will have students create a graphic organizer of electrical generation and they will be able to choose between energy sources to power that process. At the end, the class will then examine the differences and similarities between a variety of the graphic organizers strengthening their skills in comparing and contrasting.

4 th Grade Exploration of Energy from the Sun

In this section, the focus will be on the 4 th grade exploration of solar energy. One objective for this portion of the unit is for students to know that solar energy can be collected passively in the form of heat or converted actively into electrical energy. A secondary objective is to look at variables that affect how much energy can be captured from the sun during the differing activities. One strategy that will be employed is the use of scientific experimentation. Scientific experimentation is an important part of the overall science curriculum as it helps develop inquiry and deductive reasoning skills which are critical to the discipline of science; not to undermine the fact that students simply enjoy experiments, thus increasing the level of classroom engagement.

During the three activities where students collect the energy of sun through the use of water collectors, solar houses, and photovoltaic cells, students will be practicing scientific process skills by following the steps of the scientific method throughout. Students will keep a laboratory notebook of each experiment in which they will record their hypothesis, procedure, observations and data, results and conclusions. The use of this particular strategy helps accomplish several things: 1) The teacher has an ongoing record to use to assess how learning is progressing and what concepts may need review 2) The students get in class practice using the steps of the scientific method which they will have to use independently to complete science fair projects 3) This method helps support school-wide goals of increasing writing within the content areas and 4) For my body of ELL students, this will re-enforce complicated science vocabulary like "hypothesis" and "variable". For the duration of these scientific experiments, students will work in partner pairs. I have found that with proper selection of laboratory partners, this type of cooperative learning can be quite effective. Firstly, for many of the experiments, one set of hands is simply not enough whereas more than two sets of hands generally leaves one students without anything to do. Secondly, it allows me to pair up students who are strong readers and writers with students who need more assistance in that area, so that the students themselves become helpmates to their partners rather than relying solely on teacher assistance.

5 th Grade Exploration of Energy from Wind and Water

This section will focus on the 5 th grade exploration of energy from wind and water. The overarching objective is for students to understand how energy from wind and water can be used to do work ("work" will be defined through a scientific lens of the ability to displace a load using a force). A second objective would be to examine how wind and water energy can be transformed into usable electricity. One similarity between the 4 th and 5 th grade activities surrounding the exploration of their particular energy source is that hands-on constructivist activities will be continued to be used. However, the activities will differ greatly in the underlying scientific process skills that they promote. Whereas the 4 th graders focused on scientific experimentation, the 5 th grade students will focus on technological design.

Technological design is the building of products and systems to meet human needs. The reason for my choice of this teaching strategy is that research shows that technology-related activities provide a rich ground for learning science when they focus on (a) designing and testing artifacts and (b) critical analysis and explaining performance failures of artifacts.[17] Throughout the four activities students will do just that. Students will work in cooperative pairs to construct, test, and optimize performance of water wheels, a simple windmill, and a more complex wind turbine. To ensure that work remains equitable within the groups, teams will be assessed using an observation checklist with teacher expectations clearly laid out beforehand. I have found that this has been an extremely effective tool in managing classroom behavior during activities as well as ensuring that true cooperation is occurring within pairs. 5 th grade students will also keep a notebook throughout their activities, but rather than utilizing it for recording experiments, students will use it to sketch out ideas, take notes during testing, and assist them in developing new ideas. A secondary strategy employed in the use of the notebook is for students to journal about their ongoing learning. This strategy will help students begin to think meta-cognitively about their own learning. The use of notebooks also helps our school support the larger goals of improved communication skills in the content area of science.

Culminating Activities for All Students

This final section will focus on culminating activities in which both 4 th and 5 th grade students will engage. The primary objective of this part of the curriculum unit is to allow students to demonstrate their new found knowledge and to allow the teacher to assess the end results of the unit. The strategy employed is to allow students to demonstrate their learning in a variety of ways that will allow them to draw from their own personal strengths. Students will have a degree of choice in the type of medium(s) they use to express their learning. Options will include visual displays and artifacts, demonstrations, as well as written, oral and PowerPoint presentations. A secondary objective is that students will share their understanding with other students. This will happen in two ways: 1) students will formally present energy information in a 3 rd grade classroom setting and 2) students will do less formal presentations at a school-wide "Energy Fair". This strategy works because when students act as "teachers" of the information, it helps them internalize the information and learn it at a much deeper level. Another aspect of the strategy is that the creation of an energy fair fosters community involvement (in this context, community is defined as the school community) as well as student leadership through the planning and organization of the event. Finally, I have employed this strategy because it allows all students to achieve success; everyone has something to show-off and share.

Classroom Activities

Activity #1

This first activity will be the introductory lesson for the entire unit and is for both 4 th and 5 th grade students. The objective for this lesson is for students to gain a basic and tangible understanding of what energy is and that energy has different forms. Rather than leading in with a description or definition of what energy is and following it with an activity to demonstrate that property, this activity will have a more open ended activity followed by classroom discussion. The activity is designed around students visiting stations that demonstrate different properties or types of energy. Students will take with them a worksheet that has a repeating question on it. The question is very simple: Based on what you did/saw in station # (1, 2, 3, etc.), what do you think energy is? The strategy behind this activity is for students to construct their own definition of energy drawing from their own body of prior knowledge rather than information dispensed by the teacher. Teacher can advise students that they will likely have a variety of answers for the question, depending on the station. Listed below are ideas for six possible stations, but the options are numerous and only limited by your imagination. Instructions for the station as well as any additional instructions necessary for safety or classroom management concerns should be posted on index cards near the station.

1. The first item in the station is a cup with a balloon stretched tightly over the opening. On the surface of the balloon a small amount of pepper should be sprinkled. Other items at the station should include a tuning fork(s) and a shallow tray of water. Instructions posted at the station should guide students to strike the tuning fork and touch the surface of the water, observing what happens. The second instruction is to strike the tuning fork again and hold it near the ballooned surface of the cup without actually touching it. Student should be able to observe the pepper "jumping" on the balloon surface.
2. This station should contain both an activated chemical hand warmer and an activated chemical ice pack. The instructions should guide students to feel each item and think about where the heat and the cold might be coming from.
3. This station should contain a radiometer and a flashlight. The instructions should guide students to experiment by holding the flashlight at varying distances and observe changes in movement of the radiometer.
4. This station should contain a simple catapult made out of a large paper clip and an unsharpened pencil.

Slide pencil through the closed end of the paper clip between the two loops. Lay the paper clip along the body of the pencil and as you push down on the pencil it should form a catapult that can be used to toss small wads of paper quite a good distance. A visual demonstration of how this works can also be viewed online. [18]

5. This station should contain one D-cell battery, one small piece of copper wire, and one 1.5 volt flashlight bulb. The instructions for student should challenge them to see if they can make the bulb light up.
6. This station should include a set of "happy" (Neoprene®) and "sad" (Norsorex®) balls. Students should drop each of the balls and observe what happens. Although the balls appear to be identical, the happy ball will bounce back like expected whereas the sad ball will simply land with a thud and no rebound. These balls can be purchased at many different scientific supply companies, but are available through Arbor Scientific for $ 3.95 per pair. (Product ID P6-1000)

After the class has had an opportunity to visit each station, students should return to their seats for classroom discussion. Have students share what preliminary ideas about or definitions of energy they discovered. A list of ideas can be kept on the blackboard or overhead projector and the teacher should categorize the students responses by energy forms (without labeling them) so that at the end of the lesson students should start to be able to get an intuitive picture of what some of the different forms of energy are.

Activity #2

This activity is for 5 th grade students and involves the construction of an overshot waterwheel. The primary objective for this lesson is for students to gain a concrete understanding of how water's energy can be harnessed to do work. A secondary objective is for students to think about the variables in waterwheel construction that can be changed to optimize its performance. This lesson will be done in partner pairs. For each group you will need: two styrofoam plates (or large thick cardboard discs), one 12" piece of small diameter wood dowelling, 9 small bathroom size plastic cups, a small amount of modeling clay, a piece of plastic cord cover (the style that is open on one side), string, ruler, protractor, pencil, scissors, stapler, small items to put in one cup that will serve as the load (marbles, erasers, paperclips, etc.), and a source of water such as a faucet or garden hose.

First, have students locate the center of each plate. Using the protractor have students draw four diameters at 45° angles on one of the plates to locate eight of the plastic cups. Each cup will then be stapled with the opening of the cup parallel to each of the eight lines. (See Figure 4.0) Start a small hole in the center of each plate with the scissors and slide through the dowelling. The cups should now be sandwiched in between both plates with the dowel protruding from either side. Use a small piece of modeling clay to secure the dowel to the outside of each plate. If you have older students or the teacher wants to do this step, you may also affix it with hot glue which will be more permanent, however caution should be used not to use so much glue that it burns all the way through the styrofoam. Next, tie a piece of string in a circle around the lip of the last cup, leaving two free ends to be tied in a triangle above the lip of the cup for balance. This will become a container for lifting the load. The remainder of the string should be tied to the middle of the dowel protruding from one side. Your waterwheel is now ready for action. The piece of plastic cord cover will be used as a "flume" to direct your water to overshoot the water wheel. (See Figure 4.0) If plastic cord cover is unavailable you may also fashion one out of a few layers of aluminum foil bent into a channel like shape.

The water wheel should be held by the students using the other side of the dowel, without the cup attached, as a handle. Direct students to hold it securely, but not so firmly that the dowel won't spin in their hand. Have students test out their water wheels starting with just the empty cup first. As the water flows through the cups on the wheel, the wheel will spin-wrapping the string around the dowel and lifting the cup (load). Students can then experiments with different load weights to see how much their water wheel can handle as well as adjusting the flow of water. Towards the end of the lesson students should be asked to think about how they could design a water wheel (using household items) capable of doing even a greater amount of work. Students should use their laboratory notebooks to draw out their design with a list of materials as well as writing a short description of why they chose their materials and believe them able to create the best water wheel. If you wanted to extend the activity to homework or give extra credit, you could challenge students to construct their new designs at home and bring them into the classroom to test.

Figure 4.0

Activity #3

This activity is for 4th grade students and will be the first activity done when the two groups diverge to explore their separate energy source(s). The focus of this lesson is collecting energy from the sun passively in the form of heat. The primary objective of the lesson is for students to understand that the sun gives us energy in the form of heat and that different materials absorb that heat in varying amounts. A secondary objective is for students to understand that dark materials absorb more of the sun's energy than lighter materials. This activity will be performed in partner pairs. The materials needed for each group include: four plastic cups (clear or white), black paint, a 1-cup measuring cup, water, sand, soil (potting or garden soil), 4 submersible thermometers, laboratory notebooks, and a pencil. The teacher will also need a stopwatch. Prior to beginning the lesson, one cup for each group should have its interior painted with black paint and be allowed to dry.

Students will keep a notebook of this experiment following the steps of the scientific method. It is up to the teacher whether or not he/she wants the students to write out the entire procedure in their notebook and draw out their own chart for recording data or if a worksheet is to be used where students just fill in the information and attach it to their notebook. This decision can be made based upon whether you want students to practice their writing skills or whether you want to shorten the length of time needed to perform the experiment. The important part is that students make their own hypotheses before performing the experiment, collect and record their own data, and make conclusions from their results. In their hypothesis, students should predict which material they think is going to heat up fastest (rank the materials #1-4) as well as which material they think is going to cool down the fastest (rank the materials #1-4).

To begin the experiment have students fill the black painted cup with 1 cup of water, fill cup #2 with one cup of water, fill cup #3 with one cup of sand, and fill cup #4 with one cup of soil. Place one thermometer into each cup. This experiment will last for 40 minutes once started. The cups will be placed for 20 minutes in the sun with temperature readings being taken every 5 minutes and for 20 minutes in the shade with temperature readings being taken every 5 minutes. It is important that students take a 0 minute base reading (once you are outside) of each material because they will not necessarily be the same temperature and classroom thermometers usually vary by several degrees. The teacher will be the time-keeper for the activity and announce when it is time to read the temperature, as well as when that time is approaching so that students can get ready. Partners should take turns either reading or recording. If students have not used thermometers before, a brief lesson beforehand on how to read thermometers would be in order. After all data is collected, students should calculate the temperature change in the sun by subtracting the starting temperature from the ending temperature for each material. Students should then calculate the temperature in the shade by subtracting the ending temperature from the starting temperature. Students should now compare which materials saw the greatest increase in temperature in the sun and decrease in temperature in the shade. Classroom discussion can be opened up on why students believe each material behaved as it did. Teacher should guide discussion, through questioning, in a way that leads to appropriate scientific conclusions without going to the extent of providing "the answers". Students should now write their statements of conclusion in their laboratory notebooks.

Appendix

Appendix of Standards Met in Curriculum Unit

Ilinois Learning Standards

ILS 11A. (Science) Know and apply the concepts, principles and processes of scientific inquiry. During the 4 th grade exploration of solar energy, they will use scientific inquiry as they conduct experiments. This inquiry will include formulating questions, collecting data, making observations, and drawing conclusions. Records of this process will be created using laboratory notebook entries.

ILS 11B. (Science) Know and apply the concepts, principles and processes of technological design. During the 5 th grade exploration of energy from wind and water, they will design and build prototypes of wind and water turbines. The students will also test the effectiveness of their design and use problem solving skills to optimize the performance of their designs.

ILS 12C. (Science) Know and apply concepts that describe properties of matter and energy and the interactions between them. The focus of the unit is for students to gain a basic understanding of energy, learn about energy sources, energy transformations, and how to make informed energy choices.

ILS 13B. (Science) Know and apply concepts that describe the interaction between science, technology and society. As students explore different energy sources, they will examine the way that energy use impacts our society in terms of politics, economics, environment, and human health. They will also examine the technologies behind the alternative energy sources of solar, wind, and water.

ILS 15B. (Social Science) Understand that scarcity necessitates choices by consumers.

Students will examine the impact of scarcity of fossil fuels on current and future consumer choices through the use of case studies.

ILS 3A. (Social Emotional Learning) Consider ethical, safety, and societal factors in making decisions. Through the use of case studies and decision trees, students will learn to consider a variety of factors and impacts of making decisions in regards to energy.

WIDA Consortium Standards (World-Class Instructional Design and Assessment)

WIDA Standard 3 English language learners communicate information, ideas and concepts necessary for academic success in the content area of Science. Due to a high population of English Language Learners (ELLs) within our school, it is mandated that students also meet English Language Proficiency Standards within all content areas. Throughout the unit students will be increase their use of science content related vocabulary and be able to communicate new science content through written assignments and oral presentations.

Resources

Teacher Resources

Arquin, Michael. Wind Turbine Blade Design-Kid Wind Project. 2006. http://www.kidwind.org/PDFs/Blade%20Designv3.pdf (accessed July 10, 2009). A complete sets of lesson plans for wind turbine blade design and optimization. Links provided to plans to build your own classroom turbine from pvc.

Bauman, Shelly, Constance Beatty, Sara Brownell, and et al. Wind Is Energy. Manassas, VA: National Energy Education Development Project, 2008. A storybook to be read to kids with basic information on wind as an energy source as well as related activities.

Baumen, Shelly, Constance Beatty, Sharon Brownell, and et al. The Sun and Its Energy. Manassas, VA: National Energy Education Development Project, 2008. A flipbook that introduces young students to simple words related to the sun and its energy.The book includes accompanying activities.

Bernstein, Lenny, Peter Bosch, Osvaldo Canziani, and et al. Climate Change 2007: Synthesis Report. Scientific Report, Geneva, Switzerland: Intergovernmental Panel on Climate Change, 2007. A comprehensive report providing an integrated view of climate change. This document provides a framework for understanding anthropogenic drivers of climate change.

Eastland, Clare. Teaching About Energy: Practical Activities for 7 to 11 year olds. Exmouth, Devon, Great Britain: Southgate Publishers, 1999. An excellent source of hands on activities to teacher students about energy sources and technology.

Energy Information Administration. Energy Price Impacts on the U.S. Economy. April 10, 2001. http://www.eia.doe.gov/oiaf/economy/energy_price.html (accessed July 10, 2009). An excellent government website for a breakdown of how energy prices affect the overall U.S. economy. Links provided to many informative statistical graphs.

—. Who are the major players supplying the world oil market? January 28, 2009. http://tonto.eia.doe.gov/energy_in_brief/world_oil_market.cfm (accessed July 10, 2009). A brief article describing the historical of oil imports in this country and the political implications of foreign controlled oil.

Gibilisco, Stan. Alternative Energy Demystified. New York: McGraw Hill, 2007. A self-teaching guide to understanding alternative energy.

"Global energy demand to grow 50%, U.S. agency predicts." The New York Times. June 25, 2008. http://www.nytimes.com/2008/06/25/business/worldbusiness/25iht-25energy.13977482.html (accessed May 24, 2009). An article that discusses the growing U.S. demand for energy and some of the future consequences of that demand.

Indiana Department of Education. Energy, Economics, and the Environment: Case Studies and Teaching Activities for Elementary School. New York: National Council on Economic Education, 2006. A book of elementary curriculum that focuses on teaching about energy, economics, and the environment through the use of case studies and decision making.

Krulwich, Robert. "Its All About Carbon." All Things Considered. National Public Radio, May 1, 2007. The first in a series of five radio programs about climate change. Links are provided for the remainder of the four shows.

National Academy of Sciences. Electricity from Renewable Resources: Status, Prospects, and Impediments. Washington D.C.: The

National Academies Press, 2009. This report analyzes current contributions and likely future impacts from the various renewable energy resources.

National Geographic. "Energy for Tomorrow: Repowering the Planet." 2009 Special Edition on Energy. A complete special edition of National Geographic magazine dedicated to looking at energy from many different perspectives.

National Wildlife Federation. Climate Classroom: What's Up With Global Warming? 2007. http://online.nwf.org/site/PageNavigator/ClimateClassroom/cc_naaee_guidelines (accessed July 10, 2009). A teacher resource for lesson plans and activities to help young students learn about global warming. The resource contains online and activities and games to use with your students.

Patch, Stephen C, Richard P Maas, and Kimberly R Sergent. "An Investigation of Factors Related to Levels of Mercury in Human Hair." Technical Report #05-150, Environmental Quality Institute, University of North Carolina-Asheville, 2005.

Patterson, Graham. "Alan Greenspan claims Iraq war was really for oil." Times Online. September 16, 2007. http://www.timesonline.co.uk/tol/news/world/article2461214.ece (accessed May 24, 2009). An article discussing Alan Greenspan's view on the war in Iraq with good insight into the politics behind energy.

Roth, Wolff-Michael. "Learning Science Through Technological Design." Journal of Research in Science Teaching 38, no. 7 (2001): 768-790. A report on a decade of research on how and why students learn science through designing technology.

Sachs, Jeffrey, and Peter Annin. "Seminar." Water: Sustaining Our Blue Planet. Chicago: The Field Museum, May 13, 2009. A discussion hosted by The Field Museum that explored how water issues are related to poverty, health, and climate change on local, regional, and global levels.

Wolfson, Richard. Energy, Environment, and Climate. New York: W.W. Norton & Company, Inc., 2008. A comprehensive textbook that provides an excellent source of reference when discussing energy, environment, and climate.

Student Resources

Energy Information Administration. "Energy Kid's Page" http://www.eia.doe.gov/kids/energyfacts/index.html (accessed July 10, 2009). A website with facts about energy for children including games, puzzles, and classroom activities.

National Energy Education Development Project. "NEED Energy Infobooks". http://www.need.org/EnergyInfobooks.php (accessed July 12, 2009). A great book that students or teachers can print out that is full of great pictures and information about energy.

National Wildlife Federation. "Climate Classroom". http://www.nwf.org/climateclassroom/ (accessed July 10, 2009). A website full of fun activities and games for kids focused around global warming.

Peterson, Christine. Alternative Energy. Danbury, CT. Children's Press. 2004. From the True Book series, this text gives students a fundamental understanding of alternative energy sources through simple reading and colorful pictures.

Thornhill, Jan. This is My Planet: The Kids' Guide to Global Warming. Toronto, Canada. Maple Tree Press. 2007. A comprehensive look at global warming and what children can do about it. Straightforward approach but rather than being frightening, it helps children feel hopeful and empowered.

Endnotes

[1] Wolfson, Richard, "High Energy Society" in Energy, Environment, and Climate, 34.

[2] "Global energy demand to grow 50%, U.S. agency predicts." The New York Times. June 25, 2008. http://www.nytimes.com/2008/06/25/business/worldbusiness/25iht-25energy.13977482.html (accessed May 24, 2009).

[3] Who are the major players supplying the world oil market? January 28, 2009. http://tonto.eia.doe.gov/energy_in_brief/world_oil_market.cfm (accessed July 10, 2009).

[4] Patterson, Graham. "Alan Greenspan claims Iraq war was really for oil." Times Online. September 16, 2007. http://www.timesonline.co.uk/tol/news/world/article2461214.ece (accessed May 24, 2009).

[5] Energy Information Administration. Energy Price Impacts on the U.S. Economy. April 10, 2001. http://www.eia.doe.gov/oiaf/economy/energy_price.html (accessed July 10, 2009).

[6] Monthly Energy Review, January 2001, Table 1.8, Annual Energy Outlook 2001, National Energy Modeling System.

[7] Who are the major players supplying the world oil market? January 28, 2009. http://tonto.eia.doe.gov/energy_in_brief/world_oil_market.cfm (accessed July 10, 2009).

[8] Ibid

[9] Wolfson, Richard, "Environmental Impacts of Fossil Fuels" in Energy, Environment, and Climate,153.

[10] Patch, Stephen C, Richard P Maas, and Kimberly R Sergent. "An Investigation of Factors Related to Levels of Mercury in Human Hair." Technical Report #05-150, 9.

[11] Wolfson, Richard, "Environmental Impacts of Fossil Fuels" in Energy, Environment, and Climate,149.

[12] Wolfson, Richard, "Environmental Impacts of Fossil Fuels" in Energy, Environment, and Climate,146.

[13] Patch, Stephen C, Richard P Maas, and Kimberly R Sergent. "An Investigation of Factors Related to Levels of Mercury in Human Hair." Technical Report #05-150, 9.

[14] Bernstein, Lenny, Peter Bosch, and Osvaldo,Canziani, et al. Climate Change 2007: Synthesis Report, 72.

[15] "Global energy demand to grow 50%, U.S. agency predicts." The New York Times. June 25, 2008. http://www.nytimes.com/2008/06/25/business/worldbusiness/25iht-25energy.13977482.html (accessed May 24, 2009).

[16] Bernstein, Lenny, Peter Bosch, and Osvaldo,Canziani, et al. Climate Change 2007: Synthesis Report, 72.

[17] Roth, Wolff-Michael. "Learning Science Through Technological Design." In Journal of Research in Science

Teaching, 768.

[18] "World's Simplest Office Catapult". You Tube. January 23, 2008. http://www.youtube.com/watch?v=X8QlbYiYrgE&feature=related (accessed June 10, 2009).