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The Power of the Sun

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Overview

This unit is designed to engage sixth grade students using hands-on investigative activities that will increase their awareness of solar energy. The primary objectives comply with the New Mexico standards for Science for sixth grade and will be identified at the beginning of each activity described in this unit. The unit will be a study about solar energy and it will entail mini lessons on the sun's composition, positioning in our solar system, role it plays as the Earth's closest star, and an investigation and discussion about energy and its transformation into various forms. The culminating activity will be the construction of a model solar car. The objective is to have students begin thinking about renewable energy and the need for alternative fuels in their future. Although the unit is designed to be taught in its entirety and, therefore, will take several weeks to teach, it is plausible for a teacher to extract a particular lesson plan if time does not allow for the teaching of the complete unit. Students will use scientific thinking and practice to understand the processes of scientific investigations and use inquiry and scientific ways of observing, experimenting, predicting, and validating to think critically. This unit will be taught in the fall so that students will take full advantage of the sun's inclination for the construction of their model solar car, as well as be able to observe deciduous trees using light energy to conduct photosynthesis.

Introduction

I first became interested in environmental issues twenty years ago when I attended a conference in Denver, Colorado on the greenhouse effect. As many people know, the greenhouse effect is a naturally occurring phenomenon attributed to the composition of our Earth's atmosphere. When light energy from the sun reaches the Earth some of it is reflected back to space and the rest is absorbed. Al Gore's book, An Inconvenient Truth, has an illustration of this process [1]. The light energy is absorbed and the Earth is warmed. The energy not absorbed by the Earth is then re-radiated back toward space as long-wave radiation or infrared waves. This outgoing long-wave radiation is partially trapped by greenhouse gases. These gases trap some of the heat inside the atmosphere of the Earth and enable the Earth to be a habitable environment for people and other living organisms. This greenhouse effect keeps the surface temperature of the Earth at approximately 10 degrees centigrade and without the greenhouse effect, the average surface temperature of the Earth would be approximately -25 degrees centigrade. Human habitation on Earth would be impossible at these temperatures. Carbon dioxide is one of the most abundant greenhouse gases and currently the number one topic when discussing climate change. Other greenhouse gases include methane and water vapor, which trap and radiate the Sun's light energy in all directions, warming the Earth's surface and atmosphere [2].

The Greenhouse Effect and Global Warming

Why is it important to understand the greenhouse effect and its impact on global warming? Today, it is hard to watch the news or read the paper without hearing or seeing something being discussed about carbon dioxide emissions (CO_2). Up until recently, the last two hundred years or so, the Earth's atmosphere has been relatively stable and existing in a place of equilibrium that provided the perfect balance of gases for human habitation. Current research is showing that CO_2 levels are increasing at an alarming rate compared to historical trends of the past [1]. Unfortunately, this isn't new news. The prediction that burning of fossil fuels would increase the amount of carbon dioxide in the atmosphere and lead to global warming was made as early as 1896 by the Swedish chemist Svante Arrhenius — he also coined the phrase "greenhouse effect" [3]. The industrial revolution had a tremendous impact on pollution and started the increase in greenhouse gas production by humans, who are responsible for the current levels of CO_2 in the atmosphere, which is warming our Earth and causing dangerous scenarios for us in the near future. The hottest year on record from 1860 to 2005 was the year 2005 worldwide [1]. It is this warming trend that has made global warming a household phrase. How did this happen?

Although many greenhouse gases are naturally occurring, we humans have accelerated the rate of their production and release back into the atmosphere. The Intergovernmental Panel on Climate Change — a panel of more than 2,500 scientific experts from 130 countries — concluded in their report in the spring of 2007 that CO_2 emissions have grown between 1970 and 2004 by about 80% and represented 77% of total global greenhouse gas emissions in 2004 [14]. Carbon dioxide has increased since pre-industrial times from 280 parts per million to 381 parts per million [1]. In the United States, transportation accounted for nearly 2 billion metric tons of our national CO_2 emissions; a full 33% of the carbon dioxide we put in the atmosphere as a nation comes from tailpipes, this stated by Environmental Action [15]. Fossil fuels are fuels formed in the ground from the remains of dead plants and animals. It takes millions of years to form fossil fuels. Oil, natural gas, and coal are fossil fuels. The rest of the carbon dioxide comes from destroying vegetation, mainly the felling of forests; trees soak up CO_2 when alive and store it, but release it when they are cut down and/or burned [3]. The other greenhouse gases, methane and nitrous oxide, are given off by burning fossil fuels, as well as by vegetation. Nitrous oxide is also emitted by fertilizers and methane is released into the atmosphere by rice paddies and cattle. It is the rate and the amount of these gases being release into our atmosphere that concerns scientists today. What will happen to the Earth and its inhabitants as the temperature rises?

The Effects of Global Warming

It is predicted that the level of CO_2 will double from the concentration of CO_2 in the atmosphere before the Industrial Revolution; approximately 14 billion tons of carbon a year in 2056 will be emitted. Global Warming will lead to a redistribution of heat from the Equator to the poles, which drive wind and ocean currents like the Gulf Stream [1]. These currents have followed the same patterns for years and a disturbance would have incalculable consequences for all of mankind. The average worldwide temperature is around 58°F and even an increase as small as 5°F will have a major impact especially on the poles, which in turn will change weather patterns [14]. The unpredictable nature of climate change during this time of global warming will have devastating effects on agriculture worldwide. In the past when the world was not as heavily populated, people had the opportunity to migrate to more hospitable climates and regions around the globe, but with the current population at over 6 billion people it is difficult to fathom where anyone would go to seek refuge on an already overcrowded planet.

Another consequence will be the rise of sea levels around the globe. Within the course of the next 100 years, we will see the sea levels increase by a meter or more. This will impact many urban areas living along the coast such as Manhattan, Los Angeles, and many others major metropolitan areas in which millions of people will be affected. Many islands will be under water and the Nile Delta, which is densely populated, is sinking and it is reported that by the year 2050, up to 19% of Egypt's cultivable land, home to 16% of the population, could disappear [9]. Many of us are all too aware of the temperature changes that have increased the intensity of hurricanes, as demonstrated by the damage caused by Hurricanes Katrina and Rita. Heat waves have hit both the United States and Europe causing a larger number of fatalities than in previous years.

Is there a Solution?

It would appear that an easy solution to stop global warming would be to reduce the amount of fossil fuels being burned, which in turn would decrease the amount of CO_2 released into the atmosphere. Many advocacy groups such as The Carbon Neutral Group are helping both industry and individuals calculate carbon emissions [7]. Once you are aware of the amount of carbon that your everyday activities such as cooking, driving, and heating or cooling your home give off, then you can reduce your impact to the equivalent of zero by purchasing carbon offsets. The offsets fund projects that reduce greenhouse-gas emissions elsewhere by increasing energy efficiency, developing renewable energy, or restoring forests with the planting of new trees. Buying carbon offsets is one method that people are engaged in currently, but this process will not end global warming; it will, however, slow down the rate at which carbon is being emitting into the atmosphere. However, the issue of reducing greenhouse gas emissions is complicated by the fact that most of the world's energy comes from the burning of fossil fuels. The inexpensive cost of burning fossil fuels combined with their abundance and extractability has made them the number one choice of fuel for most developed countries across the globe. Coal continues to be available and China, the fastest growing country, has an abundant source and is burning this fossil fuel with little or no regulatory oversight. Therefore, they are burning a fossil fuel that is spewing out carbon at a very high rate and they are not offsetting it.

The impetus to move away from fossil fuels will be cost and necessity. For those countries dependent on oil or petroleum-based products, there will no longer be oil from which to extract in fifty years. Countries dependent on oil, such as the United States, will need to find new sources of energy. The 2004 British Petroleum *Statistical Review of World Energy* predicted that global oil reserves will be gone in 2045 with the United States running out of its oil reserves by 2015, based on known reserves and current rates of consumption ratio [4].

So, here we are in a nation that is oil dependent and yet our supply is about to run out. What's next? What is the next fuel to take us into the future? Alternatives to fossil fuels must be made a priority. Renewable energy can be generated in many different ways and several examples come in the form of wind, biomass, and solar. These energy forms are renewable and generally speaking have significantly less carbon emissions than burning fossil fuels; therefore, they are referred to as "clean energy". Technology for acquiring alternative fuels from renewable energy already exists, but the methods for storage and distribution are extremely costly. It appears that there will no longer be a single source for our energy needs. In order to reduce our CO_2 emissions, we will have to rely on a variety of energy sources. We will have to make sacrifices both financially and in the way we live our daily lives. Conservation will no longer be a "good idea"; it will be the way of life, if we are to sustain our civilizations under the heat of global warming.

Rationale

The Denver conference on the greenhouse effect piqued my interest and led me into the field of environmental education. It is my personal interest and professional background in environmental issues that drives my science curriculum. A lot of my science units focus on current environmental topics, which I integrate in the public school curriculum along with the National Science Standards. I regret that I did not learn about ecology or environmental issues until I was out of college. It is for this reason that I am highly motivated to teach my students about issues such as global warming and renewable energy.

The second reason for teaching a unit on solar energy is my geographic location in the Southwest of the United States. I teach in Santa Fe, New Mexico which is located at 35°N105°W with an elevation of 7,000 ft (2,132 m), making it the highest capitol in the United States [5]. New Mexico is ranked 5 th in the United States for total land area, 121,665 sq. mi (315,194 km2) [6]. This means that we have tremendous potential to generate solar energy. The landscape ranges from wide deserts to broken mesas to high, snow-capped peaks. New Mexico is home to two desert biomes: the Chihuahua desert in the lower half of the state and a high-desert ecosystem made up of piñon-juniper forests in the central part of the state up to the northern half of the state. The elevation ranges from around 2,000 ft up to 13,161 ft at the highest point.The combination of lots of desert landscape and high elevation lends itself to being an ideal land mass for solar power development.

As a teacher of elementary students, I develop lessons that are of high interest to my students and provide relevant hands-on activities that will engage them. Studying renewable energy is important given the current state of the world's climate and our country's dependence on fossil fuels and the near depleted state of oil. The students living in New Mexico have an advantage by having access to many projects across the state that are engaging in solar energy research as well as solar energy production and experimentation. In 2004, a project was initiated by researchers using the most efficient solar technology to construct a new power plant. The prototype for the facility is based in New Mexico and it contains 82 mirrors that focus the Sun's rays to transmit heat energy to an engine filled with hydrogen. As the gas expands and contracts from the heating and cooling, the motion drives pistons which power a generator that creates electricity. This prototype was producing 150 kilowatts of electricity a day, enough to power 40 average households. Using this kind of technology, a farm or ranch 100 sq mi in the southwestern U.S. could possibly provide as much electricity as is needed to power the entire country, according to Stirling Energy Systems, Inc. (SES) general manager Bob Liden [7]. This kind of project is exciting and accessible to my students. The geographic location and the relatively mild and extremely sunny disposition of the state of New Mexico is a favorable working environment for the students' research on solar energy and the construction of a model solar car. The earlier we are able to impress upon our students that they are the future, the sooner they will feel empowered to make positive changes. It is my belief that my students will be able to solve some of the crisis my generation is now faced with because they are getting exposed to current and relevant issues that affect each and every one of us.

Objectives

The principal objective of this unit is to develop creative, critical thinkers who are able to understand the importance of the sun as the fundamental energy source for our planet. This unit will provide elementary school teachers with hands-on activities that will integrate science and mathematics. This unit will be used in a sixth grade classroom in Santa Fe, New Mexico, but it may be adapted to other grade levels and/or geographic regions. The unit will commence with an introduction on the chemistry of the Sun; it's position in relationship to the Earth. Next, the unit will investigate the types of energy produced by the Sun. Students will be able to define energy and describe different types of energy from solar to mechanical and beyond. Students will be able to give examples of how energy is transferred from one source to another. The next lesson within the unit will be for students to understand the role of light energy in the process of photosynthesis and from here students will learn about how energy is transferred through the food chain.

Standards and Strategies

The activities and lesson plans for this unit will be based on the New Mexico Science Standards and Benchmarks which are aligned with the National Science Standards. The unit will cover elements of Earth and Space Science, Physical Science, and Life Science.

The primary focus of all of the investigations will be for students to understand the processes of scientific investigations and use inquiry and scientific methods to develop questions, design and conduct experiments using appropriate technologies, analyze and evaluate results, make predictions, and communicate findings. Students will use graphic representations such as charts, graphs, tables, models, and diagrams to present data and produce explanations. Students will all use mathematical tools and unit systems to calculate and analyze data.

Science needs to be experiential. Younger students, such as the ones I teach in sixth grade, are still very engaged in learning and are willing to try anything new. The motivation to learn is still ingrained in the mind of these students. Our job is to make meaning out of the content we are teaching and allow discovery to assist us in this process. We all would like to help our students become self-directed, life-long learners and one way we can do that is to continually engage our students with relevant subject matter and make connections for them. Before starting this unit, I will give my students a pre-test to assess their knowledge of solar energy. This will enable me to guide and focus my instruction. This assessment will be given at the end of the unit to determine how much the students will have learned.

Since at least half of my students are second-language learners, it is important that vocabulary acquisition happen in the presence of a hands-on activity or scientific investigation. When the word is paired with an object, it is easier for the students to understand its meaning and remember it; learned out of context, the word holds no meaning for the student. So, throughout this unit wherever possible, I will use models or give demonstrations to help students visualize the concept being taught. My students will work with partners or in small groups throughout the unit. This will allow for collaboration and exchange of ideas and theories throughout the learning process.

This unit will take 5 weeks to teach in its entirety. I plan on teaching it starting in early September so that we can observe the transition of seasons. I plan to spend about three hours a week on the lessons I provide here as well as others that I will add to the culminating activity of designing and constructing a model solar car.

Some lessons can be taught in isolation, but many of the lessons associated with constructing a model solar car are connected to one another and the success of the lesson is dependent on data or materials gathered in earlier lessons. The unit will begin with Earth and Space Science. Students will learn about the Sun's composition and its role in our solar system. The students will learn about the seasons and how the tilt of the Earth's axis of rotation creates them. Students will learn about the Earth's atmosphere and discuss the greenhouse effect. From here the lesson will move into Physical Science and focus on the concept of energy. Students will define energy and be able to explain the physical processes involved in the transfer, change, and conservation of energy. Next, the focus will be on Life Science and students will understand the role of light energy in the process of photosynthesis. Students will learn that plants are the producers and that all food chains and food webs are interconnected and dependent on solar energy. Finally, the unit will discuss science and society and the current state of our Earth's climate and the need for renewable energy. Students will design and construct a model solar car.

Activities

Background for Earth and Space Science

Our solar system is composed of the Sun and all things which orbit around it: the Earth, the other seven or eight planets — depending on where you stand on the Pluto debate, asteroids and comets. The Sun is 150 million kilometers (93 million miles) away from the Earth (this distance varies slightly throughout the year, because the Earth's orbit is an ellipse and not a perfect circle) [10]. The Sun is our planet's closest star and is in the middle of its life cycle. The Sun is an average star - there are other stars which are much hotter or much cooler, and intrinsically much brighter or fainter. However, since it is by far the closest star to the Earth, it looks bigger and brighter in our sky than any other star. With a diameter of about 1.4 million kilometers (860,000 miles) it would take 110 Earths strung together to be as long as the diameter of the Sun. The Sun is mostly made up of hydrogen (about 92.1% of the number of atoms, 75% of the mass). Helium can also be found in the Sun (7.8% of the number of atoms and 25% of the mass). The other 0.1% is made up of heavier elements, mainly carbon, nitrogen, oxygen, neon, magnesium, silicon and iron. The corona, the outer most layer of the Sun, is neither a solid nor a gas, but is actually plasma [10]. Many students are taught that matter only exists in three states (liquid, solid, and gas), but plasma is a unique state of matter, and it is important that students are made aware of its existence.

The Sun can be divided into six layers, from the center out, the layers of the Sun are as follows: the core (which occupies the innermost quarter or so of the Sun's radius), the radiative zone, and the convective zone, and then there is the visible surface known as the photosphere, the chromosphere, and finally the outermost layer, the corona. The energy produced through fusion in the Sun's core powers the Sun and produces all of the heat and light that we receive here on Earth.

All of the energy that we detect as light and heat originates in nuclear reactions deep inside the Sun's high-temperature "core." This core extends about one quarter of the way from the center of Sun to its surface where the temperature is around 15 million kelvin (K) (or 27 million degrees Fahrenheit (F)). 14,000,000 K is the same as 25,199,540°F and the Photosphere is a cool 19,340°Fahrenheit [10].

A third unit of temperature is used in many areas of science. This scale has its zero point at absolute zero. The unit of temperature on this scale is called the kelvin after Lord Kelvin (William Thompson), 1824-1907, and its symbol is K (no degree symbol is used). The table below will help students understand the kelvin scale in relationship to Celsius and Fahrenheit.

(table 07.05.06.01 available in print form)

Two excellent websites to help students understand the vastness of our solar system are http://www.nineplanets.org and http://www.exploratoratorium.edu/rohn/solar_system.

After helping students understand the composition of the Sun and the relative distance from the Sun to the other planets in our Solar System, I will move on to the topic of the Earth's seasonal change and rotation on its axis. The terms rotation and revolution can become very confusing for kids and it is best to demonstrate the difference with an actual model. In the following activity, students will identify the factors that cause the seasons on Earth. The activity I like to use to demonstrate the Earth's rotation on its axis and its revolution is called, "Circling the Sun". This activity along with many others, that are excellent for teaching Earth Science, can be found at the Center for Hands on Learning (http://www.handsonlearning.org). Students will work in small groups of four. This activity targets NM Science Standards & Benchmarks Strand II: Content of Science, Standard III by helping students to understand the structure of the Earth, the solar system, and the universe, the interconnections among them, and the processes and interactions of Earth's systems.

Activity

Objective: Students will construct a model that will demonstrate the Earth's rotation on its axis.

Essential Question: What causes the seasons?

Materials: a baseball size foam ball, a rubber band to represent the Equator, a small straw or drink stirrer, a sticker like a small mailing label, one toothpick broken in half, and flexible wire, flashlight or overhead projector.

Procedure:

- Prepare a model Earth by putting the straw/stirrer through the center of the Earth and this will represent the axis.
- Cut off the ends of the straw so that only 5 mm is sticking out on each end.
- Put the rubber band around the ball at the middle for the Equator.
- Place the sticker on the ball so that it goes from the top of the ball down to the Equator; this will allow you to write on the surface of the foam ball.
- Push your toothpick through the middle of the sticker into the ball and only allow about 5 mm of it to stick out.
- Put the wire through the straw/stirrer and then bend the wire around so that the left over part can create a handle to hold the model.
- Be sure that the Equator tilts at a 45° angle to the handle you created out of the bent wire.
- The handle should remain perpendicular to your hand.
- Answer the following questions by shining an overhead projector or flashlight directly onto the model.

Demonstrations and Questions

What happens to the shadow of the toothpick as the Earth rotates?

Demonstrate summer and winter. Stand with your back to the light source. Hold your model so that the wire loop (where the handle comes down) is on the other side of the ball. Rotate your Earth so the toothpick is towards the light and casts a shadow. Make a mark at the end of the shadow.

Move to the other side of the light source. Stand with your back to the light source. Hold your model so that the wire loop is towards you. Rotate your Earth so the toothpick is towards the light and casts a shadow. Make a mark at the end of the shadow.

Were the shadows the same length? Can you determine which one was summer and which one was winter? Can you use your model to show which pole gets no light in the winter? What did you do?

Conclusions

You would like each student to understand that there is a significant relationship between the angle of the Sun's rays to temperature and seasons.

Background for Physical Science

An excellent transition from the Sun's rays and the seasons is to help students understand that the same amount of light energy is being emitted whether a flashlight is being held straight up and down or at an angle (demonstrate this on a piece of graph paper with the lights out). Next, discuss how that same amount of energy is spread out more when the flashlight is held at an angle. Help the students understand that a square inch receiving light straight over head from the flashlight when it is in a vertical position is receiving more light energy than a square inch when it is tilted. This demonstration can be recalled when beginning to design and construct a model solar car.

As we have discussed earlier, our Sun is a star and it generates its own energy. Remember that the Sun is made up of gases, ¾ hydrogen and ¼ helium. The Sun creates energy by converting hydrogen to helium in its core. When hydrogen atoms are forced by high pressure and temperature to combine into heavier helium atoms, some mass is lost in the process. The "lost" mass is converted to energy equivalent to mc^2, according to Einstein. Since c, which represents the speed of light, is a large number, a small amount of mass gets converted into a large amount of energy. This process is called hydrogen fusion, and is the same energy source used in hydrogen bombs. The amazing part is that the Sun converts almost 600 million tons of hydrogen to helium in its core each second, and it is estimated that there is enough hydrogen fuel in the Sun for it to shine for another 5 billion years [12].

Gary Brudvig, Chair of the Chemistry Department at Yale University, attests to the fact that the Sun's power could provide a lot of our energy needs in the future; for example, one hour of energy reaching the Earth's surface from the Sun could power the entire planet for a year. The challenge is trying to find a way to harness and store that energy.

Energy

Energy comes in many different forms and, although the focus of this unit is on solar energy, it is important for students to know about the different forms that it can be in such as: mechanical — energy of motion; chemical energy — a form of potential energy related to the breaking and forming of chemical bonds; heat energy-produced by moving atoms and molecules; light energy — energy that is seen as visible light; sound energy — energy that is heard; electric energy — energy made available by the flow of electric charge through a conductor; nuclear energy — release by a nuclear reaction; elastic energy — energy stored in elastic materials as a result of stretching or compressing; and wind energy — energy from the movement of air from areas of high pressure to areas of low pressure. It is also important for students to learn about the law of conservation of energy which is the total amount of energy in the universe is constant. Energy can change form but cannot be created or destroyed. When energy changes form, some of the energy is lost to waste heat or sound — heat is the most common by-product of energy transformation.

In order to help students grasp the concept of energy, I will conduct a little demonstration followed by an activity to help build vocabulary about the different forms of energy. This activity covers the NM Science Standards for Physical Science which explains the physical processes involved in the transfer, change, and conservation of energy.

Mini Lesson and Demonstration to Begin Discussion on Energy

I begin my lesson on energy by turning off the lights in the room and turning on a flashlight. I ask my students what kind of energy is in use. Many students will immediately know one of the answers, light energy, and this will be a topic that I will elaborate on later in the lesson. Next, I will ask them if they think there is any other form of energy being used and I ask them to think about what makes a flashlight bulb light. Students will then start to think about the batteries inside and someone may be able to come up with chemical energy and this can lead into a discussion on how batteries work. Next, I walk around the room and ask each student to put their hand in front of the flashlight and describe what they feel. They feel heat, of course, and I tell them about the law of conservation of energy. We do a few more demonstrations to illustrate that heat is a by-product of energy transformation. We rub our hands together and we feel the heat generated between them while we are using mechanical energy; we run in place for a minute and feel our bodies warm up. As our body burns calories, we also give off heat. For vocabulary building, I write the names of the different forms of energy on index cards and write its definition on another index card and place the cards face-down on the floor to look like the old card game Concentration. My students will then take a turn trying to make a match and familiarizing themselves with the different forms of energy. If the student finds a match, I then ask them to demonstrate this form of energy or describe it in use.

Light Energy

The energy we receive from the Sun comes to us in the form of heat and light energy. We are only able to perceive visible light and this provides an excellent opportunity for students to learn about the Electromagnetic spectrum. A website promoting Photobiology has activities for students to investigate more on the subject of light energy (http://www.pol-us.net/ASP_Home/aspkids/aspkids.html). One activity that kids will enjoy is to allow them to use defractor eyeglasses to view white light that has been split just like using a prism. They can sketch the rainbow they see; see teacher resources for where to purchase these eyeglasses. From here, I will transition into plants and their need for light energy. In order to make a connection to visible light, you may want to ask your students why leaves are green. They appear green to the human eye in white light because of a special molecule; that molecule is chlorophyll. Chlorophyll molecules absorb red and blue light and transmit or reflect green light. Human perception by the retina is at 555 nanometers not far removed from the intensity maximum of sunlight at 575 nanometers, which allows us to perceive white light. A very neat project for students is to experiment with solar photography. Janice VanCleave has an activity on Chromatography in her book, A+ Projects in Biology. Another activity is to separate colors in ink so that students can see that one color of ink may be made up of several colors.

Separating the Colors in Ink Activity

Begin by cutting strips of filter paper, like that of a coffee filter, and make each strip about one-half inch wide and five inches long. Put about ½ inch of a 50:50 mixture of water and rubbing alcohol into a glass container about three-to-four inches tall. Use a water soluble marker — the students often have those Crayola sets of colored markers which would provide a lot of different colors to test — to make a spot in the middle of the paper about one-half inch from one end. It is recommended that you start with a black or brown marker first. Do not make the spot too big! Next, fold the top of the paper and hang it over a pencil into the glass so that the bottom of the paper is just in the liquid. Cover the glass so that the liquid does not evaporate and sit back and watch the ink spot move up the paper. You should be able to see the colors separate. Conclude by asking your students what color marker had the most variety of colors in it.

Background for Life Science: Photosynthesis

Plants need light energy to carry out photosynthesis. Photosynthesis is the process by which plants are able to capture light energy and use that energy to make glucose. In this process, sunlight provides the energy needed by chlorophyll to change molecules of carbon dioxide and water into glucose (a type of sugar). Light energy is actually used to chemically split a water molecule and as a result oxygen is released as a beneficial by-product. The reaction is $6\ CO_2 + 6\ H_2O$ + Light Energy —> $C_6H_{12}O_6 + 6\ O_2$. Students are often times mystified by gasses and have a difficult time grasping things that are not concrete. You can demonstrate that we breathe out carbon dioxide by conducting a simple experiment using a glass filled with limewater (calcium oxide). Limewater is used to test for the presence of carbon dioxide gas because it reacts with CO_2 to form the compound calcium carbonate. Once you have made the lime water, keep it in a sealed container like a Nalgene bottle. Place some in a beaker or glass and then put a straw in it. Ask a student to come up and blow into the lime water and observe what happens. The water should turn cloudy as the carbon dioxide is released in the water. A more advance activity demonstrating the presence of carbon dioxide can be found in Janice VanCleave's A+ Projects in Chemistry.

Students can also observe a plant giving off oxygen. This demonstration is conducting by using Elodea Plants, which are usually found in aquariums. Carolina Biological Company carries a Photosynthesis BioKit that can be purchased for this demonstration; see Teacher Resources. By demonstrating the existence of these two gases you provide students with a better understanding of the exchange between CO_2 in the atmosphere that trees utilize in carrying out photosynthesis and the oxygen produced as a waste product in this process.

Background on Solar Energy

Solar energy is one of the renewable energy sources that we currently have the technology in place to use. The problem with solar energy is that we do not have a way to store it. Solar energy is generated through the use of a solar electric system which is comprised of photovoltaic cells. These cells are thin silicon wafers with a positively charged impurity, such as Boron deposited on the surface. The parent silicon wafer is negatively charged. This forms a sandwich and within the sandwich exist a positive layer that accepts electrons and the negative layer that releases them to create a flow of current. The Photovoltaic panel works only when exposed to light and a flow of electrons moves from one layer to another. These electrons are driven by photons in the light striking them. By attaching conducting wires to the positive and negative layers, a source of power is formed that will power a radio, drive a motor, or charge a battery [13].

The electrical output of a photovoltaic panel or cell may be measured by using a voltmeter. Voltage represents the potential or pressure of electricity being produced. Power or wattage can be determined from a combination of volts and Amps. Amperes are a rate of flow for the electrical current.

In this section of the unit, I will talk about the greenhouse effect and the increasing levels of CO_2 in our atmosphere. One of the most accessible resources for this is either the movie "An Inconvenient Truth", or the book of the same title written by Al Gore. Since carbon is the main culprit in creating climate change, it is also important to make sure that our students understand its role in the environment. The National Public Radio (NPR) broadcasting service has put together a series of animated videos to educate the public about carbon. You can find these at the following website: http://www.npr.org/news/specials/climate/video/. I will use this as an introduction to global warming and also show part of "An Inconvenient Truth" so that my students understand the need for alternative fuels that are not contributing to global warming. We will discuss alternatives such as wind, biofuels, nuclear, and other fossil fuels such as coal. I will create a chart and ask the students to research and then compare alternative fuels delineating the pros and cons of each fuel and energy sources. Then, I will guide the students towards solar energy and ask them to discuss the benefits of solar. I will inform them that we are going to make model solar cars. Through a series of activities the students will have an opportunity to explore the power generated by solar cells. The students will experiment with a variety of conditions such as weather, time of day, angle of the sun, aerodynamics, etc. These mini experiments will result in the construction of a model solar car that will exhibit optimal performance based on their research and experiments. The framework and activities for this activity come directly from the National Renewable Energy Laboratory which sponsors the Junior Solar Sprint competition annually [13]. I select activities from their Junior Solar Sprint "So. . .You Want to Build a Model Solar Car" curriculum that I can apply to my students. Their curriculum is targeted more for the Jr. High student and up. I have modified their activities a little to meet my students' needs.

A list of the materials needed for the model cars can be found on the NREL website. They sell kits that provide all the raw materials for your students. I will group my students in groups of three. I find that this is a good number to insure that all group members are actively engaged in the process of making the model. In the beginning of the unit, I will demonstrate how to assemble the car but only after we have conducted several investigations that will help students utilize the Sun's power. The following lesson is two activities will help students identify variables as they experiment with their design and will address the NM Science Standard and Benchmark for Scientific Thinking and Practice by helping students use scientific methods to develop questions, generate hypotheses, design and conduct experiments as well as use mathematical ideas, tools, and techniques to understand scientific knowledge.

Activity 1 — The Sun's Power

Objective: Student will determine what time of day the sun produces the most power.

Essential Question: What part of the day is the most power produced by the sun and why is this important in the design and construction of model solar car?

Materials Needed: Solar cell, motor with propeller or spinner, sunshine.

Procedure:

- Connect the solar cell to the motor.
- Take the cell and motor outside. Color one side of the propeller on the fan.
- Observe how fast it runs, if it runs too fast to count use generalizations like it moves slow, fast, and very

fast.
Count how many times per minute the fan turns.
Conduct this observation at three different times of the day - 9 a.m., 11 a.m., and 2 p.m.
Note the weather conditions at each trial.
Repeat above steps for several days.

Observations and Data Collection:

Number of Turns Observed at Different Times of Day

Date | 9a.m. | 11 a.m. | 2 p.m. | Weather Conditions

Average

Conclusions:

At what time of day is more power produced?
What can you conclude about the impact of weather on the production of power?
Will certain kinds of weather impact the solar cell? Describe.

Activity 2 — Angle of Inclination

Objective**:** Students will measure the angle of inclination of the sun to see which angle produces the most power [13].

Essential Question**:** Why is the altitude of the sun important in acquiring solar energy?

Materials Needed**:** Data from Activity One (# of turns recorded), straw, protractor, sunshine.

Procedure**:**

Hold a straw so that it is parallel to the sun's rays and casts no shadow other than a ring.
Using your protractor measure the angle of the straw.
Do this at the same times of day used in Activity One.

Observations and Data Collection:

Record the Angle of the Sun at Different Times of Day

(table 07.05.06.02 available in print form)

Conclusion:

Do you see a pattern in the angle of the sun and the average number of turns?
What time of day would you conclude would be the best time to get the most amount of energy from the sun? How does the data you collected support your answer?
What modifications must be made in the solar panel's placement in order to maximize the power at any time during the day?

Activity 2 - Angle of Inclination Part 2

Objective**:** Students will graph the angle of inclination and the number of turns observed in Activity One.

Essential Question**:** What conclusions can be drawn from the data on the graph?

Materials Needed**:** Graph paper, data from activity 2, parts one and two, and a ruler.

Procedure**:**

> Students review data from activity 2, parts one and two and determine what time of graph they will make.
> Label x and y axes.
> Plot data and write a title.
> Create 3 questions that can be answered using the graph and write them on the back of the graph paper.

I will use two more activities that will allow the students to explore the role of simple machines. They will use rubber bands to create drive belts that will form a pulley system that can be used to turn wheels and gears. The students will also explore how a gear works and its ability to transfer force. These activities originate from the Junior Solar Sprint activities. The final product will be a solar car and students will have a demonstration day when they will display their models and demonstrate how efficient their model is at utilizing solar energy. We will conclude the activity by assessing what designs worked best and what were some of the challenges of designing a solar car. An extension of this activity will be to have the student groups research the various models of alternative cars such as electric, hybrid, bioethanol, diesel, biodiesel, and solar and present on their findings.

It is my hope upon completion of this unit my students will come away with an understanding of the scientific method and a confidence that they can design an experiment of their choosing and be able to analyze the results. I also want my students to feel empowered about their ability to find solutions to complex problems and to know that they can make a difference in the world and that their ideas are supported are valued.

Endnotes

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6. www.wikipedia.com accessed: 5 July 2007.

7. http://www.carbonneutral.com/ accessed 8 July 2007.

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11. http://www.handsonlearning.org/ accessed: 10 July 2007.

12. http://www.physlink.com/Education/AskExperts/ae639.cfm accessed: 10 July 2007.

13. http://www.nrel.gov/education/jss_hfc.html accessed: 17 July 2007.

14. http://www.ipcc.ch/ accessed: 18 July 2007.

15. Stafford, D., (Ed.). (Summer 2007). Stop global warming: all hands on deck. *Environmental Action*. Denver, CO.

Teacher Resources

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http://www.bp.com/multipleimagesection.do?categoryId=9017891&contentId=7033504

British Petroleum website dedicated to detailed analysis of various energy markets, easy to navigate through and an excellent resource for data collection.

http://www.bp.com/productlanding.do?categoryId=6848&contentId=7033471

This site is created by British Petroleum (BP) and it is their statistical review of world energy for 2007. It is an excellent resource for acquiring data on global production and consumption of fossil fuels primarily oil and gas.

Google Earth (earth.google.com)

This is an amazing tool especially for geography. A variety of aerial footage and you can put in any location on the globe and it will zoom into that spot from space via satellite. The program needs to be downloaded on your computer in order to view the images and it is free.

http://www.nrel.gov/learning/

National Renewable Energy Learning website with an abundance of information on all renewable energies for K-20 students and teachers.

http://www.eere.energy.gov/solar/cfm/faqs/

Frequently asked questions answered about solar energy from the basic to the complex.

http://www.carbonneutral.com/

A company/think tank that is working with individuals as well as large corporations to help people calculate and offset their carbon emissions.

http://www.pol-us.net/ASP_Home/aspkids/aspkids.html

A site developed by the American Society of Photobiology and promotes the study of light and living things. It has information on the Electromagnetic spectrum, photosynthesis, Circadian rhythms, and bioluminescence.

www.scitoys.com

Great site for ideas of how to make your own toys and funky things like a solar marshmallow roaster. Highly motivated kids would enjoy this site.

http://www.carolina.com

Carolina Biological Supply has everything you need to conduct almost any science experiment, plus they have an online catalog.

http://www.nrel.gov/education/jss_hfc.html

This is a great site for teachers to explore the Junior Solar Sprint competition and Hydrogen Fuel Cell cars. They explain how to build the cars and describe the competitions that are held annually.

http://www.ipcc.ch/

Intergovernmental Panel on Climate Change's website where you can download their report on effects of global warming issued in May of 2007.

Student Resources

http://www.pol-us.net/ASP_Home/aspkids/aspkids.html

A site developed by the American Society of Photobiology and promotes the study of light and living things. It has information on the Electromagnetic spectrum, photosynthesis, Circadian rhythms, and bioluminescence. Activities at the end allow students to make calculations.

Google Earth earth.google.com

Students will love this website as they navigate around the globe using geographic locations or place names. They can even find an image of their own house and zoom in on it from space.