Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
2010 Volume IV: Renewable Energy

Energy and Me: What Is My Responsibility?

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Introduction

Currently, I teach 18 fifth-grade males at King Robinson Inter-district Magnet School. We are a part of the Primary Years Programme (PYP) of the International Baccalaureate Organization, a non-profit, Swiss educational foundation that was established in 1968. The founding schools were seeking to establish a common curriculum that could be picked up and taught anywhere in the world. They strived for a curriculum that "exposed students to a variety of viewpoints." In a way that is directly aligned with the new 2010 CT Common Core of Teaching [1] inquiry is the leading pedagogical approach of the PYP.

The PYP requires us to create six transdisciplinary units of inquiry around the following themes: Who are we, Where are we in place and time, How we express ourselves, How the world works, How we organize ourselves, and Sharing the planet. In fifth grade, we have the distinction of substituting one unit for an exhibition, in which the students "analyze and propose solutions to a real-world issue or problem, drawing on what they have learned in the PYP." [2] To meet this requirement, students inquire into various global problems that interest them. In small groups, they then choose one topic to research further. At the end of the year, the students present their findings through an exhibition, which is open to the school community.

Overview of the Unit

The central idea of this unit is "The choices we make every day about how we use energy, impact our environment and our lives." In this 6 week unit, I will begin with the concept of energy. The students will brainstorm what energy is, why it's important to us, and where it comes from. From that point, I will demonstrate the different types of energy, the sources of energy, and the effects each has on the environment. I will structure my lessons by teaching about fossil fuels first and then carbon-free powers. Upon completion of instruction on fossil fuels, I will use a map to demonstrate where our reserves are, and initiate discussion on our reliance to other countries and what problems that can cause. I will use strategies like Nichols' "Turn-and-Talk" [3] to foster student discourse. Similarly, in conclusion to the lessons on carbon-free powers, I will use maps to show what countries are using these sources. I will use a bulletin board to create a large comparison matrix of all the energy sources.(refer to Appendix 5 for a sample) Throughout the lessons, we will add information to it, so the matrix will illustrate which fuels are renewable and/or carbon free. We will also use it to identify the traits and advantages and disadvantages of each energy source. We will also discuss what countries or areas are doing a better job at using clean energy. This should get the students thinking about our role as a nation and what we could or should do to help. (This meets our IB expectation of eliciting student-initiated action.) I hope that students might suggest writing letters to our government or other actions to spread public awareness of our growing problems.

After this instruction which will include various activities and demonstrations, I will ask the students to divide into small groups, so that each group may further research one energy source. I will give the students specific questions to research about their source concerning the cost, pros and cons of using that source, environmental issues it may cause, and how much of a supply exists. Being that we are an international school, I will also ask the students to focus on global trends and behaviors, not just those of the United States. The students will be able to use the comparison matrix, notes from our lessons, and information they find in the sources provided. I will provide multiple books and internet sites that the students may use for research. I will also contact experts to come in and speak to the class. I may contact someone from a power company (CL&P, Sunlight Solar, UI), business owners who have made adjustments in their company to be more environmentally friendly (Whole Foods, Stop & Shop -- with reusable bags and energy saver lighting) or other persons of interest in the community.

Upon completing their research, I will have the groups present their findings to the class. Their presentations should illustrate how greenhouse gases and other pollutants from fossil fuels create dangerous reactions in our atmosphere. They should also demonstrate how carbon-free powers are a better option for the safety of our Earth.

In response to the presentations, I will ask students to form an opinion about what sources we should pursue in the future and why. The students will write a persuasive essay that supports their position.

At this point, many environmental concerns will have been touched upon. I will spend a few class periods demonstrating some of the most serious environmental effects such as, global warming (climate change), ozone depletion, melting ice caps, deforestation, air pollution, acid rain etc., mostly attributed to the use of fossil fuels. There are numerous activities and experiments that can illustrate the dangers of these effects. One experiment, that recreates the greenhouse effect, will be highlighted in my upcoming lessons. In that experiment, we will also consider the different viewpoints that exist about climate change and students will form their own opinion on the issue.

In conclusion to this unit, we will explore conservation methods. I will highlight some of the everyday items that students commonly come in contact with such as plastic water bottles, plastic bags, and paper. We will talk about the energy and natural resources that are consumed by our overuse of these products and discuss ways we can limit our use of them (reusable bags and water bottles and using both sides of paper). We will also look at ways to conserve the energy we use as electricity. I will give the students data about the amount of energy that common household items consume. The students will brainstorm ways that they (and their families) can conserve energy. We will use a calculator and cost information from the local power company to determine how much money they can save with their chosen methods. The students will chart the potential monthly and yearly savings of their given changes.

There are many extension activities that could be done with family members including calculating gas mileage and the cost of transportation versus carpooling, tracking their waste at home, or helping families order recycling bins if they don't already have one. Through their learning, students will develop an array of topics that warrant further investigation. The students will branch off into those areas and explore human behaviors that are impacting the environment. They will research the effects of those behaviors and determine what they could do to help. This will bring them to their culminating research project for our IB Exhibition.

Classroom Discussion and Content

"What is energy and why is it important?"

Energy is often defined by scientists as the ability to do work. Energy can be divided into two categories: potential and kinetic. Potential (stored) energy includes chemical, mechanical, nuclear, gravitational, and electrical. Kinetic (working) energy includes radiant, thermal, motion, and sound. A unit of energy is known as a joule. 1 watt (w) = 1 joule for 1 second. 1 terawatt (TW) = 1 trillion watts. 10 to the 12 th power = 1 TW. In the year 2000, the mean globally energy consumption rate was 13 TW and it is expected to rise to 28 TW by 2050. [4] We depend on energy for everything we do. We need energy to heat our homes, power our vehicles, run electronics and much more.

Nonrenewables

Most of the energy we use in the U.S. comes from nonrenewable energy sources: fossil fuels (coal, oil, natural gas) and nuclear. In 2008, almost 85% of the U.S. energy consumption was from fossil fuels and another almost 9% from nuclear. [5] Fossil fuels are not sustainable because: they will someday run out, burning them has a dangerous effect on the climate, and we are dependent on untrustworthy foreigners to supply us with fossil fuels. [6] Fossil fuels are oil, coal, and natural gas formed from decayed plants and animals up to one billion years ago.

Oil

Oil, or petroleum, is the source of 37.4% of the U.S. energy consumption. [5] We have between 40 and 80 years' worth of oil reserves. [4] Oil is usually found in underground pockets in rock. It can cover up to hundreds of miles. Sometimes oil is mixed with sand, water, and clay, which can make it harder to separate. Americans used oil because there was a lot of it, it was cheaper than coal, and it created less pollution. The United States became the world leader in oil production in the late 1800s. "Oil-powered machinery enabled American factories to make many products more cheaply than the major industrial countries of Europe where coal was still used. As a result, the United States became a leader in world trade. [7]

The world's top crude oil producing countries are Russia, Saudi Arabia, United States, Iran, and China. One fourth of the oil produced in the U.S. is produced offshore in the Gulf of Mexico. The top crude oil producing states are Texas, Alaska, California, Louisiana, and North Dakota. About 53 % of the crude oil and petroleum products used in the U. S. in 2009 came from other countries. [8]

Oil that is extracted from the ground is liquid petroleum or crude oil. Crude oil is transported to a refinery through pipelines or ships. The oil can be separated into useable petroleum products. A 42 gallon U.S. barrel of crude oil will turn out 44 gallons of petroleum products (approximately 19 gallons of gasoline, 10 gallons of diesel, and other petroleum products.) It can be turned into gasoline (usually about half) for cars, petroleum gas for heating and cooking, fuel oil for heating homes and making electricity, diesel fuel for cars and trucks, and lubricating oil for motors. It is also used for products like: ink, crayons, bubble gum, dishwashing liquids, deodorant, eyeglasses, CDs and DVDs, tires, ammonia, and heart valves. The crude oil and the final petroleum products are stored in large tanks near the refinery and then transported through pipelines to other tanks all over the country. [8]

Finding, producing, and transporting, oil can be harmful to our environment. Burning petroleum products gives off the following emissions: carbon dioxide (a greenhouse gas and source of global warming), carbon monoxide, sulfur dioxide (causes acid rain), nitrogen oxides and volatile organic compounds (both of which contribute to ground-level ozone damaging the lungs), particulate matter (contributing to hazy conditions, asthma and chronic bronchitis, and sometimes thought to cause emphysema and lung cancer), lead (sever health impacts), and various air toxics such as benzene, formaldehyde, acetaldehyde, and 1, 3-butadiene (probable carcinogens). Oil is also dangerous if it is spilled into the ocean. This can happen if a ship is in an accident, it can be washed into the ocean from spills on land, or it can happen accidentally during off shore drilling. Oil can also leak into the ocean from natural oil seeps on the ocean floor. [8]

Coal

Coal, is the source of 22.6% of the U.S. energy consumption. [5] We have between 200-2,000 years of coal. [4] England and other European countries began to burn coal in the late 1700s and early 1800s. The coal was burned to make steam power to run machines. Coal produced a lot of energy but polluted the air. It remained the most popular energy source in the world until the early 1900s. [7] Coal is currently the least expensive fuel for producing electricity. [4] Coal is the most abundant fossil fuel produced in the U.S. It is nonrenewable because it takes millions of years to create. It began as a layer of dead plants at the bottom of the swamps which partly covered the earth hundreds of millions of years ago. The plants were covered with layers or water and dirt and the energy was trapped inside. Heat and pressure over time turned the plant remains into coal. [9]

In 2008, U.S. coal mines, in 26 states, produced 1,717.8 million short tons of coal. Most of the U.S. coal production comes from Wyoming, followed by West Virginia, Kentucky, Pennsylvania, and Texas. Coal is mainly found in three large regions: the Appalachian Coal Region, the Interior Coal Region, and the Western Coal Region. [9]

Most of the coal used in the U.S. is for electricity (almost 93%); the rest is used as a basic energy source in industries such as steel, cement, and paper. Almost half of the electricity generated in the U.S. is fueled by coal. Power plants burn coal to produce steam. The steam turns turbines that generate electricity. The ingredients in coal can also be separated. Industries can then use the heat and byproducts of coal. Methanol and ethylene are some of the ingredients in coal that can be separated. These ingredients can be used to make plastics, tar, synthetic fibers, fertilizers, and medicines. Coal can also be baked in hot furnaces to make coke. Coke can be used to make steel. [9]

Mining and burning coal can have several adverse effects on ecosystems, water quality, landscapes, and the environment. The combustion of coal produces five principle byproducts which can be harmful to the environment: sulfur dioxide (linked to acid rain and respiratory illness), nitrogen oxides (linked to the formation of acid rain and photochemical smog), carbon dioxide (primary greenhouse gas emission from energy use), and mercury (linked to neurological and developmental damage in humans and animals of most concern when it enters water). [9]

The Clean Air Act and Clean Water Act have forced industries to reduce the pollutants that are released into the air and water from the combustion of coal. Industry has worked with the government to find ways to reduce emissions such as sulfur and nitrogen oxides from coal burning and to find ways to make it more energy-efficient so less needs to be burned. Power plants clean coal with "scrubbers" before it leaves the smokestack. Other equipment such as catalytic converters (to remove nitrogen oxides) and electrostatic precipitators and baghouses (to remove particulate matter) also reduce mercury emissions from some types of coal. Scientists are still working on new ways to reduce mercury emissions and to address the carbon dioxide emissions from coal burning power plants. Sometimes carbon dioxide is captured and sequestered underground. [9]

Natural Gas

Natural gas is the source of 24% of the U.S. energy consumption. [5] Natural gas lies many feet beneath the ground and is made of mostly methane. It is often found alongside other fossil fuels and is created by organisms in wetlands and landfills. Geologists today use tools such as seismic surveys to find natural gas and drill wells. Some areas are on land and some are in the ocean. Gas is then brought up through a well and transported through pipelines. Byproducts such as butane and propane are separated, cleaned, and removed for other uses. The U.S. produces most of the gas that it consumes and some is imported from Canada. Natural gas is stored in underground storage systems and transported when needed through pipelines. Once in the communities, gas flows into smaller pipelines called "mains" which connect to very small lines called "services", which go directly to homes or buildings where it will be used. Natural gas can also be cooled to about --260 °F and turned into a compact form of liquid gas, which is ideal for storage and shipment. [10]

Natural gas is used to produce steel, glass, paper, clothing, brick, electricity and it is used as an essential raw material for many common products such as paints, fertilizer, plastics, antifreeze, dyes, photographic film, medicines, and explosives. In the U.S., more than half the homes use natural gas as their main heat source. It is also used for stoves, water heaters, and other household appliances. [10]

Burning natural gas produces carbon dioxide, but it is the cleanest of all fossil fuels. It has fewer emissions and leaves no ash particles when burned. Natural gas does affect the environment as it is produced, stored, and transported. Small amounts of methane can sometimes leak into the atmosphere. This is something the natural gas companies are trying to prevent. Also, exploring and drilling for gas disrupts land and marine habitats. New technology and horizontal and directional drilling help lessen the impact by being able to access a larger area by a single well. Natural gas pipelines and storage facilities have a good safety record, although natural gas leaks can lead to explosions. [10]

Nuclear

Nuclear energy from uranium is the source of 8.5% of the U.S. energy consumption. [5] Nuclear energy comes from the core of an atom (a tiny particle that makes up every object.) The energy is released through nuclear fusion (atoms are combined) or nuclear fission (atoms are split.) Nuclear power plants use this energy to make electricity. The most common fuel that nuclear plants use to produce nuclear energy is a kind of uranium called U-235, because its atoms are easily split. Uranium is a nonrenewable metal found in rocks all over the world, but this specific kind is rare. Most of the uranium produced in the U.S. in mined in the Western United States. Deposits of uranium are also found in Australia, Canada, Africa, and South America. 86% of the uranium used in the U.S. is imported. 42% comes from Australasia and Canada; 33% comes from Kazakhstan, Russia, and Uzbekistan; and 11% comes from Brazil, Czech Republic, Namibia, Niger, South Africa, and the United Kingdom. [11]

Nuclear power plants do not produce air pollution or carbon dioxide, but mining and refining the uranium requires large amounts of energy which may be from fossil fuels. A major environmental concern for nuclear power is its radioactive waste. When atoms are split, they produce radiation and radioactive materials that are dangerous to living organisms. Low-level radioactive waste is stored temporarily to reduce the level of radioactivity and then disposed of usually by burying it and covering it with clay, soil, and rocks. High-level radioactive waste may be stored permanently. The Nuclear Regulatory Commission governs all aspects of producing, handling, and disposing of nuclear energy. An uncontrolled nuclear reaction could be devastating, and could result in a widespread contamination of air and water for hundreds of miles around a reactor, but because of the strict rules and regulations, the risk of this happening is thought to be very small. [11]

Renewables

Renewable energy sources include biomass, geothermal energy, hydropower, solar energy, and wind energy. These sources can be replenished quickly and are mainly used as sources of electricity. In 2008, renewables represented less than 8% of the total U.S. energy consumption. [5]

Hydroelectric

Hydroelectric, is the source of 2.5% of the U.S. energy consumption. [5] Hydroelectric power is inexpensive, safe, and available around the world. Our future energy needs cannot be met solely by hydroelectric power, but we should continue to use water power wherever possible. It is feasible that 1.5 TW of energy can be produced by hydroelectric power. [4] Hydropower produces the most electricity of all renewable sources in the U.S. In 2008, 67% of electricity generation from renewables was from hydropower (6% of total electricity generation). Hydropower relies on the water cycle. In the water cycle, solar energy heats the surface of the water and causes it to evaporate. Next the water vapor condenses into clouds and turns into precipitation. The water flows through rivers and back into the oceans and evaporated again. [12]

Hydropower is one of the oldest sources of energy, being used thousands of years ago for grinding grain. The U.S. first began to use it for industry in 1800, but because hydroelectric power plants must be located on a water source, it wasn't widely used until it became possible to transmit electricity over long distances. Today hydropower is produced at large facilities in the West. Most dams are used to provide irrigation and flood control and a small percentage are used for electricity. The amount of energy that is produced depends on the flow and fall. Swiftly flowing water or water descending rapidly from a very high point will produce the most energy. [12]

Hydropower generators do not produce any emissions of air pollutants, but can have environmental impacts. Hydropower dams, reservoirs, and the operation of generators can obstruct migration of fish and change the natural water temperature, chemistry, flow characteristics, and silt loads. This can change the ecology and rock and land forms of the river, impacting the animal and plant life in and around the river. Greenhouse gases can also form in reservoirs and be emitted into the atmosphere. The U.S. Department of Energy is also researching ways to decrease the percentage of fish that are killed by the turbines. They hope to bring the percentage down from the current 5-10% to less than 2%. Dams can also interfere with reproduction of salmon. [12]

Tidal barrages are dams that are built across inlets. They work by filling up on the high tides and emptying through the turbine system on the outgoing tide. There are two commercial-sized barrages operating in the world, one in France and one in Nova Scotia, Canada. There is a third experimental barrage in Russia. France, England, Canada, and Russia have much more potential to use this type of energy. Tidal fences can also harness the energy of tides, and can be used in channels between two landmasses. They are made of vertical axis turbines mounted on a fence. Tidal fences are cheaper and have less of an impact on the environment than barrages, but they can disrupt the movement of large marine animals. There are plans to build a tidal fence in the Philippines. Tidal turbines are similar to wind turbines and can be located anywhere where there is a strong tidal flow. They need to be sturdy because water is dense, so they are more expensive to build but also capture more energy. [12]

Ocean waves have the potential to produce a tremendous amount of energy. It is estimated that the total coast of the U.S. could have produced 7% of the electricity consumed by the U.S. in 2008. The best sources of this energy are the west coasts of the United States and Europe and the coasts of Japan and New Zealand. There are many ways to harness wave energy, with devices that are placed underwater, on the ocean floor, or that ride on top of waves. The world's first commercial wave farm opened in Portugal in 2008. The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy is funding research and development on the Ocean Thermal Energy Conversion (OTEC) system which may be used to produce and transmit electricity in 10-20 years. This system uses the difference in temperature of surface water (heated by the sun) and deeper water (cooler) to produce electricity.

Geothermal

Geothermal, is the source of 0.4% of the U.S. energy consumption. [5] Geothermal energy is heat from within the earth, recovered as steam or hot water, and used for heat or electricity. Earth's hot core heats underground water and rocks. There are three main uses for geothermal energy. People can use hot water from springs or reservoirs near the surface, they can drill deep wells (1-2 miles deep) into the ground and pump the hot water or steam to the surface, or they can use the stable temperatures near Earth's surface to control building temperatures above ground. [13]

Geothermal reservoirs are places where large areas of naturally occurring hydrothermal resources exist. Hydrothermal resources are a combination of water and heat, most often found near plate boundaries. For example, when magma comes close to the surface, it could heat water that is trapped in fractured rock surfaces and faults. Sometimes there are no noticeable clues that an area has geothermal activity underneath it, but sometimes you will find volcanoes, hot springs, or geysers there. Geologists can drill wells and check the temperature to test for geothermal reservoirs. [13]

The U.S. is the leader in geothermal power generation. Most geothermal reservoirs in the U.S. are located in the western states and Hawaii. California has 34 geothermal power plants, producing 90% of the U.S. geothermal electricity. Nevada has 16 and Hawaii, Idaho, Montana, and Utah each have one. There are three types of geothermal plants: dry steam plants, flash steam plants, and binary cycle power plants. Ten feet below the earth's surface, the temperature remains nearly constant between 50-60 degrees F. Geothermal heat pumps use the earth's constant temperatures to heat and cool buildings. According to the U.S. Environmental Protection Agency (EPA), geothermal heat pumps are "the most efficient, environmentally clean, and cost effective systems for temperature control." They are becoming more popular in the U.S. and industry has partnered with the EPA to promote further use. [13]

Geothermal power plants release less than 1% of the carbon dioxide emissions of a fossil fuel plant and 97% less sulfur compounds (acid rain causing). Geothermal plants also use a scrubber system to clean the air of hydrogen sulfide, naturally found in the steam and hot water. [13]

Wind

Wind, is the source of 0.5% of the U.S. energy consumption. [5] We could potentially get 2 TW of energy from wind power from land and we could get even more from offshore power. This of course could not meet all of our energy needs for the future either. Also, the location is an obstacle because much energy would be lost in transmission, considering that the source would be far away from where the need is. [4] Wind is the motion of the air due to the uneven heating of the Earth's surface by the sun. In the daily wind cycle, the warm air (over land during the day and water at night) expands and rises and cooler air (over water during the day and land at night) rushes in to take its place, causing wind. Atmospheric winds are created because the land near the equator is heated more than the land at the North and South Poles. [14]

Today's wind machines (turbines) use blades to collect wind's kinetic energy to turn an electric generator to produce electricity. Wind turbines are best placed in areas with high wind speed. This can be high altitude areas or open areas with no windbreaks such as smooth, rounded hills, open plains, shorelines, and mountain gaps. Wind turbines can be small enough to power a single home or business and produce 100 kilowatts of energy or large enough to produce 5 million watts (megawatts). They can also be grouped together to form a wind farm and supply power to the electric grid. The world's largest wind farm is in Texas and has 421 wind turbines. Most turbines have a horizontal axis and typically stand as tall as a 20-story building, with three blades that span 200 feet across. Vertical-axis turbines typically stand 100 feet tall and 50 feet wide. [14]

In 2008, 34 states in the U.S. operated large wind turbines to generate electricity. The U.S. ranked first in the world for wind power capacity. The U.S. is followed by Germany, Spain, and China. Denmark is also notable because although it is ranked ninth in the world, it generates about 20% of its electricity from wind. The top wind producing states are Texas, California, Minnesota, Iowa, and Washington. Government programs have helped support wind power development in the U.S. and Europe, where most of the wind power plants in the world are located. There is potential to use wind energy along the coasts of the U.S., but some people think it will spoil the view. There are plans to build an offshore wind plant off the coast of Cape Cod, Massachusetts. [14]

Wind is a clean fuel that produces no air or water pollution. The only environmental drawback is the negative impact on wild bird populations. Some people also feel that windmills are an eyesore. [14]

Biomass

Biomass, is the source of 3.9% of the U.S. energy consumption. [5] Biomass is not very efficient because plants only store ~1% of the solar energy they absorb. In order to meet our future need of 20 TW, we would need to cover 31% of the Earth's surface with biomass. [4] Biomass is a renewable energy source made from plants and animals. Some examples of biomass are wood, crops, manure, and some garbage. Through photosynthesis, plants absorb the sun's energy. Chemical energy in biomass is released as heat when it is burned. Biomass can be burned to produce steam for electricity generation or to provide heat. The most common form of biomass is burning wood, which people have done for thousands of years. Wood was the main source of energy in the world until the mid-1800s. The United States burns about 14% of its trash and some of that is used to produce steam for heat or electricity, while reducing the amount of garbage placed in landfills. [15]

Biomass does not always have to be burned to release the energy inside; it can also be converted to other forms of energy. Rotting garbage and agricultural and human waste release methane gas which can be used to produce electricity. Landfills can collect the methane gas that it produces and treat it to be sold commercially. There are almost 400 operating landfill gas energy projects in the United States, mostly in California, Illinois, and Michigan. Some crops such as corn and sugar cane can be fermented to produce ethanol. Leftover food products like vegetable oil and animal fats can produce biodiesel. Ethanol and biodiesel are transportation fuels. Ethanol is added to all gasoline in the United States. The Federal Government has mandated that we increase the amount of biofuel used (most likely ethanol) in fuel by 2022. Some farmers collect the manure, dirt, and waste from their barns and put them in a tank called a digester. The methane gas inside the tank is separated and can be used to generate electricity for the farm or sold to the electric company. [15]

The different types of biomass fuels and the ways they are used can impact the environment in different ways. Biomass crops release carbon dioxide (and a small amount of sulfur) when burned, but as the crops are grown, they capture nearly the same amount of carbon dioxide through photosynthesis. [14] Power plants that burn solid waste must use special technology to prevent harmful gases and particles from entering the atmosphere. The environmental Protection Agency (EPA) has strict rules in place to monitor these industries and requires anti-pollution devices such as scrubbers, fabric filters, and electrostatic precipitators. Leftover ash is contaminated if the waste was not properly separated before being burned to remove items such as batteries, which should never be burned. Ash is tested for contamination and, if it is safe, it can be used to cover landfills, build roads, make cement, or to make artificial reefs for marine animals. [14] Ethanol and gasoline fuel mixtures burn cleaner but have more evaporative emissions from fuel tanks and dispensers, which can lead to the formation of harmful, ground-level ozone and smog. Carbon dioxide also forms when ethanol is burned, but can be offset by growing plants like corn and sugarcane, which absorb carbon dioxide as they grow, to make ethanol. [14] Biodiesel combustion produces less sulfur oxides, particulate matter, carbon monoxide, and hydrocarbons, but more nitrogen oxide. Again, if oils from plants are used in biodiesel the carbon dioxide emissions will be off-set. [15]

Solar

Solar, is the source of 0.1% of the U.S. energy consumption. [5] Solar energy is the only renewable resource that can alone meet our future energy needs. It is estimated that we can obtain between 50 and 1,500 TW of energy from solar energy. We would need to use a lot of land (comparable to the nation's interstate highways) to produce this amount of energy. [4] Another source estimates that covering 4% of the world's desert area with PV cells could supply all of the world's energy. The Gobi desert alone could meet almost meet the world's demand. [16] Solar energy is the sun's rays that reach the earth. Solar radiation can be converted into other forms of energy, such as heat and electricity. Thermal (heat) energy can be used to heat water or spaces. Solar energy can be converted to electricity through photovoltaic (PV) "solar cells" or through concentrating solar power plants. [16]

PV cells change sunlight directly into electricity. PV cells are made of semiconductors such as crystalline silicon or various thin-film materials, and can be grouped into panels and arrays of panels to power items such as small calculators to large power plants. Two large photovoltaic plants were completed in Europe in 2008. One was built in Portugal and one in Germany. [16]

Concentrating solar power plants generate electricity by using solar energy to heat a fluid that produces steam to power a generator. There were 11 solar power generating units operating in the United States at the end of 2008: 9 in California, 1 in Arizona, and 1 in Nevada. California has nine solar power plants in three locations. Concentrating solar power technologies there use mirrors to reflect and concentrate the sunlight onto receivers and convert it into heat. [16]

Solar energy is everywhere the sun shines and it is the Earth's most available energy source, but there are some disadvantages of using solar energy. First, the amount of sunlight hitting the Earth's surface is not constant and it is dependent upon many factors: location, time of day, time of year, and weather conditions. Second, a large surface area is required to collect the amount of solar energy we need. Also, collecting solar energy is very expensive. There are some advantages of using PV systems: sunlight is converted directly to electricity and does not require bulky generator systems, any size PV array can be installed quickly, and there is minimal environmental impact no water is required and there are no by-products. [16]

Classroom Lessons: (3 class periods)

Objectives: Students will understand the greenhouse effect and global warming. They will also identify their own behaviors that contribute to the greenhouse effect and what they could do to help. They will also understand different viewpoints that exist.

Day One: (Use Appendix 1)

Lesson Introduction:

I will access students' prior knowledge, asking them: "What do you already know about the greenhouse effect?" and "What questions do you have about the greenhouse effect?

Experiment:

I will explain that we are about to recreate the greenhouse effect through an experiment. I will take 2 one--liter Mason jars (without lids) -- each filled with 2 cups of cold water and two drops of blue food coloring. I will place a fish tank thermometer inside each jar. I will wrap one jar in a gallon-sized plastic baggie and tell the students that these jars will be placed in direct sunlight. I will then ask the students to make predictions: "After one hour, which jar will be the hottest?"

I will have the students break up into groups and collect the same materials so that they may each create the experiment. Students will be given a handout to record their predictions and observations throughout the experiment. Students will begin by recording the current temperature of the water and making a prediction about what the temperature of each jar will be in one hour. They will then place their jars in the direct sunlight (on a window sill or outside).

Student Research:

During the hour, I will let the students research the greenhouse effect. This can be done in several ways and can be independent, small group (as centers), or whole class. They can use multiple resources like books, magazines, newspaper articles, and online websites and videos. A handout with questions that relate to the central idea can help students keep track of their new learning. They can then break up into small groups to discuss their answers.

As the jars remain in the sun, students can check them periodically and plot their temperatures every 15 minutes.

Conclusion:

Students record the final temperature after one hour and compare the results to their initial predictions. Students can talk about the results with their group mates and compare the experiment with what they learned about the greenhouse effect during their independent research.

Assessments:

Students will answer the following question independently: (allow 5-10 minutes)

"Why did the water in the bagged jar become hotter?"

Once the written responses are collected, students can share out their ideas about the greenhouse effect to the whole class. Some may want to explain it through a diagram or other visual. Students should be encouraged to communicate what they learned in various ways.

Other ways of assessing student learning include using a rubric to monitor their progress on: following directions for the experiment, recording predictions and observations, completing a handout with questions, making a line graph that shows the temperatures of each jar, and generating an oral and/or written explanation of the experiment.

Day Two: (Use Appendix 2)

Lesson Introduction:

I will access students' prior knowledge, asking them: "What did you learn yesterday about the greenhouse effect?" and "How does the greenhouse effect contribute to global warming or climate change?"

Instruction:

I will revisit the greenhouse effect and demonstrate it again (a short video or diagram will work best for visual learners). I will explain the theory that the rising levels of greenhouse gasses in the atmosphere are contributing to climate change.

Activity:

I will break the students into small groups with heterogeneous reading levels and ask them to read the U.S. Environmental Protection Agency's (EPA) "State of Knowledge" on climate change. I will ask the students to highlight important information. I will then ask them to fill in a graphic organizer with bullet points under "what's known", "what's very likely", and "what's not certain".

Conclusion:

I will show the students a short clip from Al Gore's movie, "An Inconvenient Truth", where he demonstrates the correlation between the levels of carbon dioxide in the atmosphere and the global average temperature. I will then give the students data that further demonstrate the correlation and ask them to graph the data in small groups.

Assessments:

Students will answer the following questions independently: (allow 5-10 minutes)

What is your point of view? Is the rising level of carbon dioxide in the atmosphere causing climate change? Are human behaviors causing climate change? What is our responsibility?

Other ways of assessing student learning include using a rubric to monitor their progress on: participation in whole-class discussion, participation in small group, completing the graphic organizer, and generating an oral and/or written response to the assessment questions.

Day Three: (Use Appendixes 3 and 4)

Lesson Introduction:

I will access students' prior knowledge, asking them "How do humans impact the greenhouse effect and global warming?"

Instruction:

I will revisit the EPA's "State of Knowledge" and ask the students to recall what is "known", "very likely", and "not certain". I will remind them that scientists are certain that human activities are changing the earth's atmosphere by increasing the levels of greenhouse gases like CO_2, which tend to warm the planet.

Activity:

I will break the students into small groups and ask them to look back at their notes from the last two class periods. I will ask them to reflect on what they have learned and brainstorm a list of human behaviors that contribute to the increase in greenhouse gases in the atmosphere. Next, they will brainstorm a list of things they can do to help.

Conclusion:

I will put up a large cause-effect-solution graphic organizer on the overhead or on chart paper for us to fill in as a class. The effect will already be filled in with "Increases the level of CO_2 and other greenhouse gases in the atmosphere, tending to warm the planet very likely causing climate change." I will ask students to share out a human behavior (cause) that causes an increased level of greenhouse gasses in the atmosphere, such as "driving cars." I will then ask students to come up with solutions to the behaviors, such as "carpooling".

Assessments:

Using their notes and the large graphic organizer that we filled in, students will independently come up with a personal action plan based on the following questions. (Allow 10-15 minutes) What personal behaviors do you want to change about yourself? What are three goals you would like to set for yourself in response to what you have learned about the global warming? How will you accomplish these goals?

Other ways of assessing student learning include using a rubric to monitor their progress on: participation in whole-class discussion, participation in small group, completing the graphic organizer, and generating an oral and/or written response to the assessment questions.

Appendix 1

The Greenhouse Effect & Global Warming

Day One:

Experiment

	A	B (in bag)
Current Water Temperature	____________	____________
Predicted Water Temperature in one hour	____________	____________

On a separate piece of paper, create a data table to record the temperatures of the water every 15 minutes for the next hour. After one hour, use graph paper to create a line graph to represent the temperature changes of each jar.

Research:

Explain what the Greenhouse Effect is and how it contributes to global warming (in your own words):

____

____

How can global warming impact our environment?

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____

Assessment question:

Explain why one jar became hotter.

____

____

You may also draw a diagram

Appendix 2

Day Two:

With your group, read the "State of Knowledge" about climate change. Fill in some key points in each of the 3 columns below.

What is Known	What is Very Likely	What is Uncertain

Assessment questions:

What is your point of view? Are human behaviors causing climate change? What is our responsibility? Explain. (Continue further research if necessary.)

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Appendix 3

Day Three:

What human behaviors contribute to global warming?

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With your group, think about some things you can do to help stop global warming.

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Assessment questions:

What personal behaviors do you want to change about yourself?

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What are three goals you would like to set for yourself in response to what you have learned about the global warming?

____

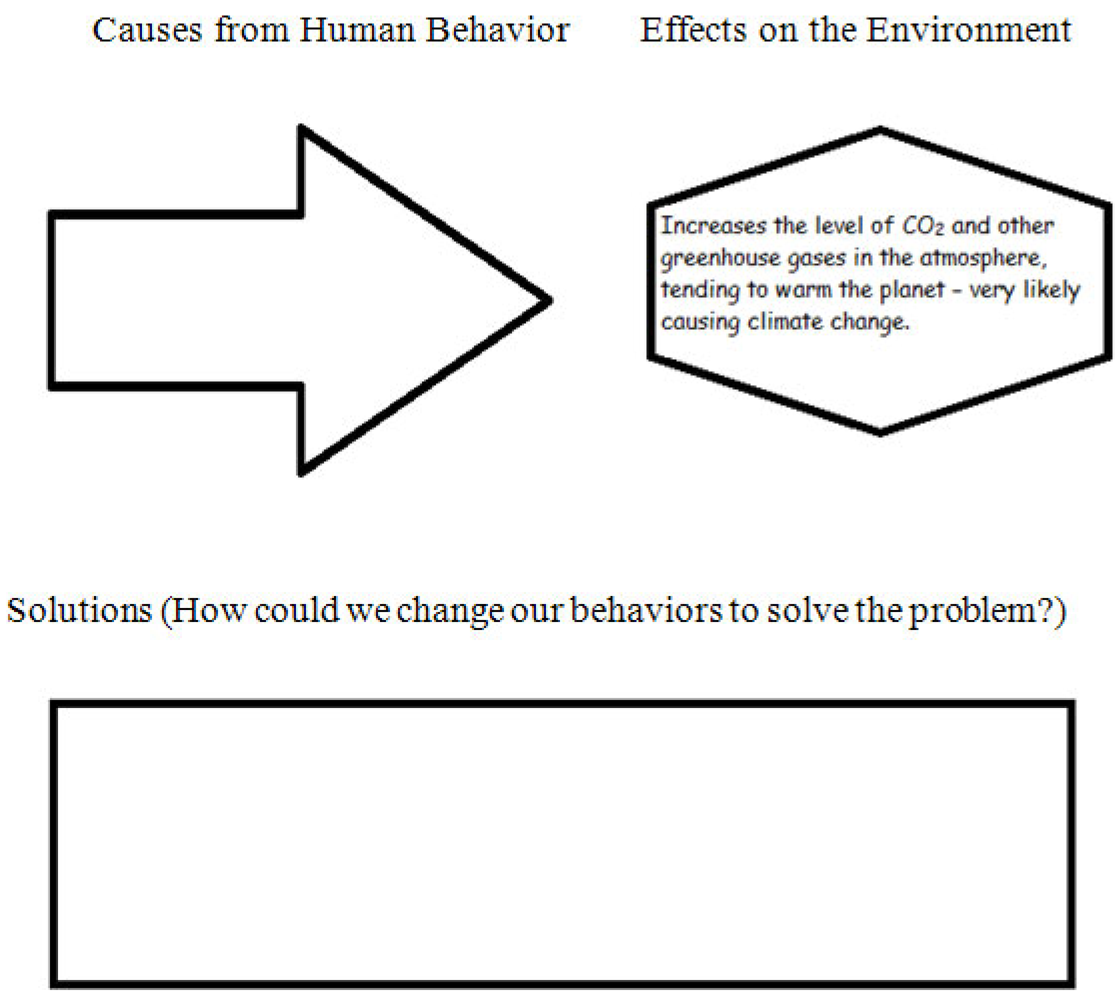
____

How will you accomplish these goals?

____

____

Appendix 4



(This would ideally go on the overhead or large chart paper. It should be filled in with the students. They can get ideas from their notes as well as their own personal experiences.)

Appendix 5

Sample: Comparison Matrix of Energy Sources

Energy Source	Pros	Cons	Efficiency	% of U.S. Energy Consumption	Locations of Production in the U.S.	Locations of Production in the world
Biomass						
Hydropower						
Geothermal						
Wind						
Solar						
Oil (Petroleum)						
Natural Gas						
Coal						
Nuclear (Uranium)						

This would be a great bulletin board for students to interact with.

Sources listed in the bibliography that could be used to complete the matrix are:

EIA Annual Energy Review, 2008, available online at:
http://tonto.eia.doe.gov/kids/energy.cfm?page=about_forms_of_energy-sources

http://www.nucleartourist.com/basics/why.htm

Appendix 6 Implementing District Standards:

Science

Expected Performances in Inquiry, Literacy, and Numeracy

B INQ.1 Make observations and ask questions about objects, organisms and the environment.

B INQ.2 Seek relevant information in books, magazines, and electronic sources of information.

B INQ.5 Use data to construct reasonable explanations.

B INQ.6 Analyze, critique and communicate investigations using words, graphs and drawings.

B INQ.8 Search the web and locate relevant science information.

B INQ.10 Use mathematics to analyze, interpret and present data.

Social Studies

Content Standard 13: Limited Resources

Students will demonstrate that because human, natural and capital resources are limited, individuals, households, businesses, and governments must make choices.

Language Arts

Standard 1.2 Students interpret, analyze and evaluate text in order to extend understanding and appreciation.

Standard 1.4 Students communicate with others to create interpretations of written, oral and visual texts.

International Baccalaureate Organization

Standard A2

The school promotes international-mindedness on the part of the adults and the students in the school community.

Appendix 7 Annotated Bibliography

McKay, D. Sustainable energy-- without the hot air. UIT Cambridge, 2009.

(Explains various ways to obtain sustainable energy.)

Lewis, S. Nathan, Chemical Challenges in Renewable Energy. California Institute of Technology. Pasadena, CA, 2004.

(Describes alternative energy sources' potential ability to meet our future energy needs).

An Inconvenient Truth, Dir. Davis Guggenheim, Perf. Al Gore, DVD, Paramount, 2006.

(Provides some arguments and evidence about Global Warming.)

Nichols, Maria, Comprehension Through Conversation. Heinemann Publishing, 2006.

(Describes strategies for developing student discourse.)

CT Department of Education, Common Core of Teaching, 2010

(States the professional teaching standards by content area.)

Harwood, Jessica, Should We Drill for Oil in Protected Areas? Mondo Publishing, New York, NY, 2007.

(Illustrates different viewpoints about drilling in protected areas.)

State of knowledge, U.S. EPA, 2009 http://www.epa.gov/climatechange/science/stateofknowledge.html (accessed 6/28/2010).

(Lists what is known about climate change.)

Bag--Ban Debate, Scholastic, 2009 (www.Scholastic.com) Accessed 3/3/2010.

(Illustrates dangers of plastic bags and gives conservation ideas.)

http://energyquest.ca.gov/projects/greenhouse.html Accessed 6/28/2010.

(Provides science experiments on energy. I adapted the greenhouse experiment in my lessons from this website.)

http://tonto.eia.doe.gov/kids/energy.cfm?page=about_home--basics accessed 4/8/2010

(Explains the different types of renewable and nonrenewable energy.)

http://tonto.eia.doe.gov/kids/energy.cfm?page=biomass_home--basics accessed 4/8/2010

(Explains properties, history, and effects on the environment from using biomass energy.)

http://tonto.eia.doe.gov/kids/energy.cfm?page=coal_home--basics accessed 4/8/2010

(Explains properties, history, and effects on the environment from using coal.)

http://tonto.eia.doe.gov/kids/energy.cfm?page=about_forms_of_energy--sources accessed 4/8/2010

(Explains the different sources of energy.)

http://tonto.eia.doe.gov/kids/energy.cfm?page=stats accessed 4/8/2010

(Gives 2008 statistics on energy sources.)

http://tonto.eia.doe.gov/kids/energy.cfm?page=wind_home--basics accessed 4/8/2010

(Explains properties, history, and effects on the environment from using wind.)

http://tonto.eia.doe.gov/kids/energy.cfm?page=solar_home--basics accessed 4/8/2010

(Explains properties, history, and effects on the environment from using solar.)

http://tonto.eia.doe.gov/kids/energy.cfm?page=hydropower_home--basics accessed 4/8/2010

(Explains properties, history, and effects on the environment from using hydropower.)

http://tonto.eia.doe.gov/kids/energy.cfm?page=geothermal_home--basics accessed 4/8/2010

(Explains properties, history, and effects on the environment from using geothermal.)

http://tonto.eia.doe.gov/kids/energy.cfm?page=nuclear_home--basics accessed 4/8/2010

(Explains properties, history, and effects on the environment from using nuclear.)

http://tonto.eia.doe.gov/kids/energy.cfm?page=natural_gas_home--basics accessed 4/8/2010

(Explains properties, history, and effects on the environment from using natural gas.)

http://tonto.eia.doe.gov/kids/energy.cfm?page=oil_home--basics accessed 4/8/2010

(Explains properties, history, and effects on the environment from using oil.)

http://tonto.eia.doe.gov/kids/energy.cfm?page=coal_home--basics accessed 4/8/2010

(Explains properties, history, and effects on the environment from using coal.)

EIA Annual Energy Review, 2008

(Supplies statistics about energy use in the U.S. in 2008.)

http://www.nucleartourist.com/basics/why.htm (Accessed 7/4/2010)

(Compares the different energy sources. Use to complete the comparison matrix)

Appendix 8 Student websites

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http://www.eia.doe.gov/kids/index.cfm

http://tonto.eia.doe.gov/kids/

http://www.eere.energy.gov/kids/

http://climate.nasa.gov/kids/index.cfm

http://energyquest.ca.gov/projects/index.html#saving

http://epa.gov/climatechange/kids/global_warming_version2.html

Teacher websites

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http://energyquest.ca.gov/teachers_resources/index.html

http://energyquest.ca.gov/projects/greenhouse.html

http://www.epa.gov/climatechange/science/stateofknowledge.html

http://www.epa.gov/climatechange/index.html

http://www.epa.gov/climatechange/science/index.html

http://www.epa.gov/climatechange/basicinfo.html

http://www.epa.gov/climatechange/emissions/ind_calculator.html

http://www.epa.gov/climatechange/emissions/downloads10/US-GHG-Inventory-2010_Chapter2-Trends.pdf

http://www.uwsp.edu/cnr/wcee/keep/Mod1/Whatis/energyresourcetables.htm#Wattages_of_Small_and_Medium

www.Scholastic.com

http://www.nucleartourist.com/basics/why.htm

Notes:

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[1] CT Department of Education, Common Core of Teaching, 2010

[2] Today's Students for Tomorrow's World, An International Education, IBO, 2002

[3] Nichols, Maria, Comprehension Through Conversation, Heinemann, 2006. (p 65-7)

[4] Lewis, S. Nathan, Chemical Challenges in Renewable Energy. California Institute of Technology. Pasadena, CA, 2004.

[5] EIA, Annual Energy Review, 2008.

[6] MacKay, J.C David, Sustainable Energy -- without the hot air, 2008.

[7] Harwood, Jessica, Should We Drill for Oil in Protected Areas? Mondo Publishing, 2007. (p 1-9)

[8] EIA Energy Kids -- Oil, http://www.eia.doe.gov/kids/energy.cfm?page=oil_home--basics (accessed 4/28/2010)

[9] EIA Energy Kids Coal, http://www.eia.doe.gov/kids/energy.cfm?page=coal_home--basics (accessed 4/28/2010)

[10] EIA Energy Kids Natural Gas, http://www.eia.doe.gov/kids/energy.cfm?page=natural_gas_home--basics (accessed 4/28/2010)

[11] EIA Energy Kids Nuclear, http://www.eia.doe.gov/kids/energy.cfm?page=nuclear_home--basics (accessed 4/28/2010)

[12] EIA Energy Kids Hydropower, http://www.eia.doe.gov/kids/energy.cfm?page=hydropower_home--basics (accessed 4/28/2010)

[13] EIA Energy Kids Geothermal, http://www.eia.doe.gov/kids/energy.cfm?page=geothermal_home--basics (accessed 4/28/2010)

[14] EIA Energy Kids Wind, http://www.eia.doe.gov/kids/energy.cfm?page=wind_home--basics (accessed 4/28/2010)

[15] EIA Energy Kids Biomass, http://www.eia.doe.gov/kids/energy.cfm?page=biomass_home--basics (accessed 4/28/2010)

[16] EIA Energy Kids Solar, http://www.eia.doe.gov/kids/energy.cfm?page=solar_home--basics (accessed 4/28/2010)