Curriculum Units by Fellows of the National Initiative
2013 Volume V: Energy Sciences

Energy Usage and Conservation: My Impact on the World

Curriculum Unit 13.05.01, published September 2013
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Rationale

On May 10, 2013 the National Oceanic and Atmospheric Administration reported that the levels of carbon dioxide (CO_2) in the atmosphere had risen to 400 parts per million (400 ppm). Even though there are seasonal circumstances that contribute to the increase and/or decrease of CO_2 in the atmosphere (for example, CO_2 levels lower during the summer since leaf growth pulls out billions tons of carbon out of the air), this new milestone points to the fact that such high readings had not happened in the last 2 to 4 million years. The only solution to change this rapidly growing, and eventually catastrophic, pattern is to slowly move away from fossil fuels burning in the next 50 to 100 years. [1]

One of my initial goals in developing this unit was to make room for more Science in my classroom. As a self-contained fifth grade teacher, I find it very challenging to have the time, in an increasingly demanding daily schedule, to prepare hands-on materials and activities readily available for class. Tulsa Public Schools pacing calendar lists a unit on matter and energy that I inevitably simplify by studying states of water, kinetic and potential energy, and collaborating with parents in a hands-on unit about heat. However, with the headlines of May 10, I feel studying energy over time, more consistently and at a deeper level, is even of more capital importance to all educators and world citizens, especially children, adolescents and young adults. We are at a point in which we are creating a future we will depend upon for survival. However, the young generations are the ones to be most impacted by our understanding of the problems we face and the sustainable solutions we develop. It is, therefore, more imperative than ever to bring to our classes a clear understanding of energy as the source of survival for every civilization on Earth and, with that, the possibility of continual growth and development.

As an alternative to the diminishing blocks of sustained-teaching time in the classroom, I tend to develop interdisciplinary units. The logical integration of Science and Mathematics has allowed me to have one strong unit per semester. This present unit however, apart from Mathematics, will also have strong Language Arts (Reading/Writing) and History components and it is planned for 7-9 weeks. I will not be able to discuss those other subjects/themes in detail here but I will mention them briefly so that you can also find ways to lead students' understanding of the concepts across the disciplines –I have found that it is such recurrence, from different perspectives, that gives students the possibility of retaining and mastering the content.

From our district Science pacing guide and energy saving initiative, I am selecting two main specific themes for this unit: i) classification and transference of energy; and ii) energy conservation. These objectives are embedded in five process standards which according to Jon Muller are "statements that describe skills students should develop to enhance the process of learning." Our district incorporates all process standards in every one of the Science units: 1) Observation and Measurement; 2) Classification; 3) Experimentation; 4) Interpretation and Communication; and 5) Inquiry.

Division of the Unit

This unit will start with one background knowledge/summer activity, which opens and ends the unit. It will then progress into 3 sections, each one taking about two 45-minute blocks, and 1 last section which should take about three 45-minute blocks: 1) Energy: definition, sources and storage; 2) Fossil fuels; 3) The environment, pollution and global warming; and 4) Solar and Wind Power.

Energy: definition, sources and storage

Without energy nothing could be done; societies wouldn't have been able to survive and flourish; all the plant and animal kingdoms would not have had any chance of continued existence; the world would have gradually perished and the Earth would be another uninhabitable planet in the Milky Way. If these are hypothetical considerations of a past that did not happen, they can also turn out to be the nightmares of the future. The current debates about the amount of energy available to meet our needs, the security of the energy systems, and the impacts the extraction of some sources of energy have had, and will have, in the environment have been the object of closer looks and examination. [2]

In the elementary school classroom, direct experience provides tangible notions for earlier conceptualizations of heat as a type of energy: in the summer, we have felt perspiration and learned to seek shade to avoid the heat. Our first ancestors most likely had similar experiences and once fire was conquered, and wood became the main fuel, this broad understanding of heat grew and made possible new experiences, like living in a cave and bringing fire, a new form of heat, inside. With fire domesticated and a home, new opportunities arose to see how objects changed from cold to hot, or vice versa, in the presence or absence of heat. Later on, heat was found to offer the possibility of transforming materials from raw to cooked, solid to liquid (and gas), as well as transforming rocks, creating art and protecting the body.

Next, work was added as in the classic example of rubbing sticks together to start a fire. However, it was also discovered how fatigue followed more arduous work: the more effort to push or pull was exerted, the more tired one felt; the logical conclusion was that there was a direct correlation between the force and the distance with the amount of work done. [3] Energy as the ability to do work is easily grasped from the scenarios above. And, doing work can also leave us without energy and the need for rest or food to replenish the system. Every animal knows biologically how to do these things, but we wonder little about how energy has been stored and is at hand to keep everything alive.

The main source of heat, and energy, is the Sun. Nuclear reactions, occurring at the core of it, in temperatures ranging from 5600?C to 6000?C, make possible that 70% of that energy, as electromagnetic radiation, be absorbed by the Earth, and the rest reflected back into the atmosphere. [4] The temperatures of the Earth depend on a fragile balance of this energy hitting our planet and the re-radiation of what is not absorbed into space.

The Sun's light or radiation plays an extra role in the creation of other types of energy. For instance, wind occurs when the Sun's unevenness in reaching the Earth allows pockets of cooler air to come in when heat starts rising. Parallel to this, a similar process happens in the oceans since they also get unequally heated by the Sun's rays; this irregularity, and the subsequent fluctuations of cooler and hotter air creates tremendous energetic power in the ocean currents.

A broader categorization of energy, as potential and kinetic, brings even other types into consideration. Potential or stored energy is subdivided into chemical, mechanical, nuclear and gravitational; kinetic or working energy is subdivided into radiant, thermal, motion, sound and electrical. In our vehicles, we can see many of these energies occurring or being transformed: we fill the tanks with fuel, commonly gasoline, which holds chemical energy and is transformed into heat when we start the car. Immediately, the mechanisms in the car allow heat, changed into gases, to increase and press onto pistons; this action creates mechanical energy which gives us the possibility of driving the car. In some situations, though, cars crash; and, occasionally, car pieces fly in the impacts. They fly because the potential energy in the unmoving parts of the vehicle changes into kinetic in the collision; at the same time, we can trace this kinetic energy back to the chemical energy in the gasoline that started the process.

And, what's the origin of the chemical energy in the gasoline? It comes from refined petroleum, extracted from deep reservoirs which, throughout millions of years, have been formed. Heat and pressure acted on decomposing trees, plants and grasses; as they were buried deep into the earth, their energy was kept in place. This energy was, at the same time, created thanks to sunlight in the process of photosynthesis. Thus, we return to the Sun as our main source of light and energy.

With the example of the car, we can see that energy cannot be created nor destroyed, only transformed. This natural occurring principle is known as the First Law of Thermodynamics or the Law of Conservation of Energy: "no new energy arises spontaneously and none is lost." [5] This is an important formulation: if the total amount of energy in the whole universe, and on the Earth, is consistent, it will then always end up somewhere, most likely in a different form. This acts as a guideline for decisions regarding energetic systems and their efficiency, as well as amounts that are lost as heat in the processes.

However, even though energy is constant, the sources may not be infinite. The Sun will certainly continue burning for millennia but, are all the sources we use capable of sustaining the continual, and growing, demand for energy? A further division sheds some light into this issue.

Renewable vs. nonrenewable sources of energy

The most prevalent use of energy is to power our cars, keep us warm in the winter and cool in the summer. The United States relies mostly on petroleum, natural gas, coal, propane and uranium to meet these needs. These are nonrenewable sources since they have been created over a long period of time and cannot be replenished as fast as our energy consumption continues and increases.

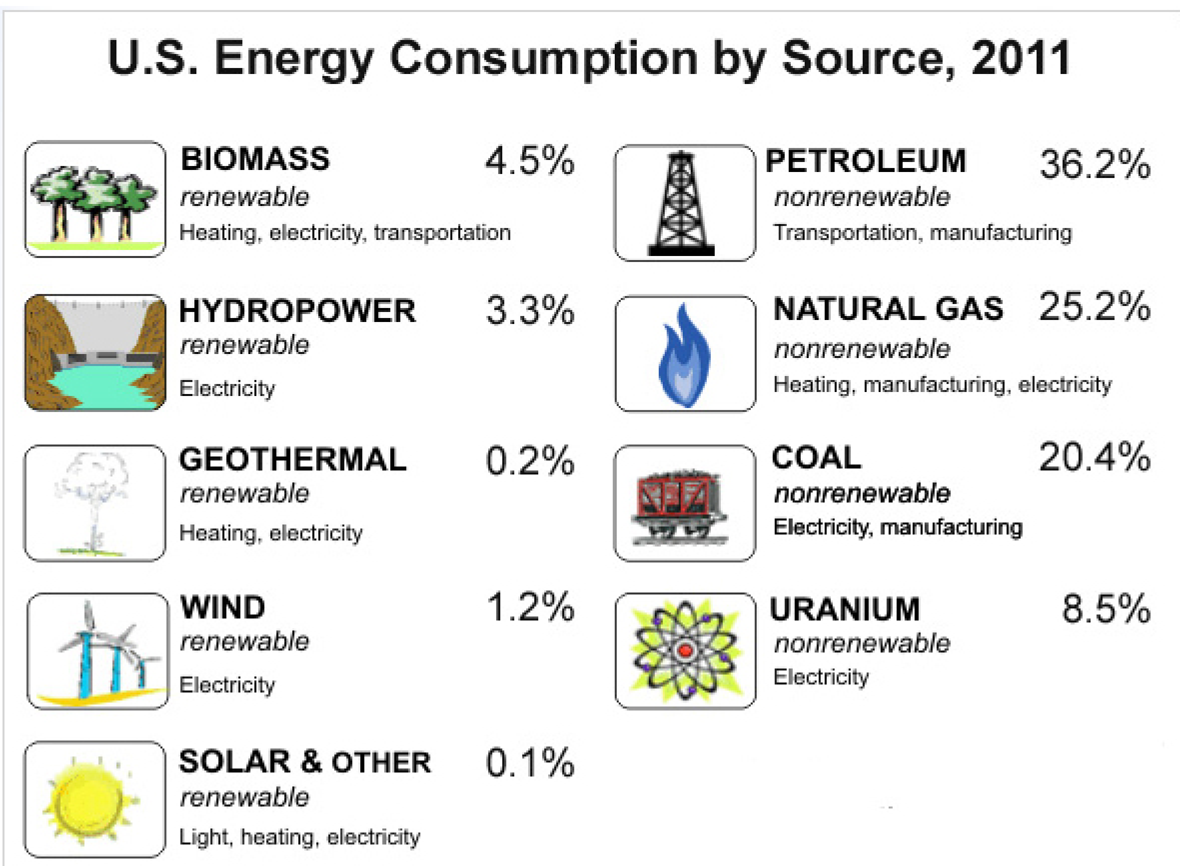
This has been known for a long time; the American, and world, governments, citizens and industries have tried to minimize the effects a lack of nonrenewable sources would have in our society by developing technologies that can harvest energy even closer to the inextinguishable sources. Biomass (organic matter, especially from plants), geothermal energy (internal heat from the earth), hydropower (energy of water), solar energy, and wind energy are all renewable sources.

Following the First Law of Thermodynamics, both renewables and nonrenewables can be converted into secondary energy sources. Two of these sources, commonly used, are electricity and hydrogen. They are considered rather transporters which store and distribute energy in accessible ways to be promptly used. However, both electricity and hydrogen cannot be harvested in site because they are created from other energy sources: firing coal helps create electricity, and most hydrogen comes from natural gas. In the laboratories, scientists are experimenting with the separation of the H_2O bond in water through a process called electrolysis.

Energy consumption in the United States

The use of renewable sources of energy has certainly grown in the last decade. However, technology advances are still trying to make the systems more affordable since, at the present time, they tend to be more expensive than some of the nonrenewables. At the same time, technological improvements have made it possible to be more efficient in the extraction of nonrenewables that were previously thought of as invaluable or too costly to produce. The newest nonrenewable sources of energy have expanded the market and seem in a trajectory to enlarge it even more. Some of these are categorized as "unconventional oil" since "their development depends on the advance of technology." [6] They include liquids that accompany the production of natural gas, oil sands, extra heavy oil, tight or shale oil, and oil shale. Production of natural gas has also grown to now encompass shale gas and methane hydrate, natural gas stored in ice. [7]

The following chart summarizes the energy consumption of renewables and nonrenewables for the United States in 2011.



Source: U.S. Energy Information Administration, *Monthly Energy Review March 2012* (Public Domain)

Fossil Fuels

It is said that all of the Earth's population can survive a whole year with only fifty minutes of the solar energy we receive. [8] At the same time, nature has found ways to store the Sun's energy when light is not present, i.e. transform it from solar energy into biological/chemical energy. Through the complex process of photosynthesis, leaves in all the different types of vegetation in the planet (and even some bacteria!), [9] use the Sun's light to produce carbohydrates ($C_6H_{12}O_6$) and release oxygen (O_2). However, the photosynthetic reaction takes place because carbon dioxide (CO_2) and water (H_2O) are also present; all these atoms and molecules form the traditional chemical representation of photosynthesis:

$$6\,CO_2 + 6\,H_2O + \text{Light Energy } (hN) \longrightarrow C_6H_{12}O_6 + 6\,O_2$$

From the equation, when CO_2 and H_2O interact in the presence of light, several complex reactions take place that regroup and add atoms until carbohydrates ($C_6H_{12}O_6$) are produced and O_2 is released. When breathing, we exhale the CO_2 plants need for photosynthesis and, in exchange, we receive oxygen. This makes photosynthesis a life-sustaining process.

This stored, photosynthetic energy in the leaves of plants is at the bottom of every web of life or food chain; as animals and man consume plants directly or indirectly, this potential energy can then be converted into kinetic energy (work). What's more, through thousands of years and earth processes, plants have been transformed into carbon, petroleum, and gas, the fossil fuels that, according to the Energy Information Administration (EIA) in the chart above, have the highest percentages of use in powering our country.

Petroleum

Petroleum or crude oil is extracted from deep inside the earth and ocean floor to be refined or separated into products like gasoline, diesel, and jet fuel. It is also extensively used in manufacturing goods we use in daily life, like tires, crayons, DVDs, etc. It is a very efficient source of energy since one barrel (about 43 gallons) of petroleum can yield 45 gallons of useable fuel; [10] that is, there is a gain when the crude oil is being processed.

Even though the world has been using petroleum extensively since the late 1800s, it is calculated that we have only used 1 out of a total of 12 to 16 trillion barrels (2008 figures); it is argued that if we eventually transition away from a fossil-fuel energy economy it will not be for a lack of supplies but rather because of better-quality energy sources substitutes. [11] This argument has challenged the "peak oil" theory which claims a decline in oil production because a maximum of extraction has been reached. In fact, there have been five times in the petroleum history when it was claimed we had reached a peak and there would not be new resources to develop or major advances in oil production. However, in spite of a decline from 1985 to 2008, production has been steadily increasing. [12]

Geologists use diverse procedures for finding oil; these range from examination of surface rocks and topography, sometimes aided by satellite images, to seismology "creating shock waves that pass through hidden rock layers and interpreting the waves that are reflected back to the surface." [13] When the site has been selected, a rig is built and the drilling operations start. Once the well's final depth is reached, the drilling apparatus is removed, and the flow of oil into the well starts; a pump is later set upon the well head. From the well, petroleum is transported through an interconnection of pipelines that brings it to the refining industries. In the US, although there are 31 states, including coastal waters, where crude oil is produced, 56% comes from only five states: Texas, Alaska, California, North Dakota, and Oklahoma. [14]

Natural Gas

In the last two decades, the natural gas industry has been revitalized. New technologies, diversification and findings have made it more available and cheaper, surpassing coal as one of the main energy sources. Additionally, most of the natural gas used in the US is actually produced in the US which helps our economy become less reliant upon importing energy sources from other parts in the world. This fossil fuel is commonly used for heating and cooking, but it is becoming an important source for generating electrical current and powering motor vehicles.

Like petroleum and coal, natural gas was formed through the decaying of plants and animals (organic matter) accumulated in layers, changed to rock, and trapped deep inside the earth. Even though it was originally a byproduct in the production of petroleum, nowadays, it is transported through pipelines from the petroleum fields to the manufacturing industries. New, and once considered challenging, natural gas reservoirs are been exploited and studied with great success and estimates figures are skyrocketing. Fraccing or fracking, also known as hydraulic fracturing, is one of the most recent technologies through which underground rocks are fragmented allowing the gas to flow out. [15] Other natural gas breakthroughs include tight gas, shale gas, coalbed methane and methane hydrate.

The main component of natural gas is methane (CH_4), a gas made up of one carbon atom and four hydrogen atoms; other gases like butane and propane are also obtained when natural gas is produced. Because of its composition, even though when CO_2 is released at the moment natural gas is burned, the amount is half as much as for coal per unit of energy. [16]

Coal

Coal is the most abundant and used fossil fuel: 40% of the world's electricity comes from it. [17] Just like petroleum, coal or carbon has taken millions of years to form through pressure and heat which helped keep its energy from photosynthesis stored. Historically, after the extensive use of wood as fuel and the eventual devastation of forests, coal became an easy and cheap energy source to extract. It is excavated through two methods: surface mining and underground mining. The former is less expensive and relies on machines to remove top soil and surface layers of rocks under which lies the coal seam; underground mining, on the other hand, needs elevators to send miners deep into the earth where they use machines to dig for carbon.

Around 35% of the coal production in the US is destined to the creation of electricity. A power plant burns coal to create steam which, in turn, moves turbines to produce electricity. The ingredients in coal can also be separated (for example, methanol and ethylene), and industries can make tar, plastics, fertilizers and medicines out of it.

The environment, pollution and global warming

Energy sources are needed to keep life and civilizations developing. However, our overreliance on fossil fuels, gradual, prolonged, and increasing dramatically parallel to population growth, has created havoc in our planet. Pollution has been a constant since man discovered fire and its fuel, but habitat damage has reached dangerous levels, and global warming now forecasts times of uncertainty, chaos and destruction. Since fossil fuels have been the energy source of choice in the last two hundred years or so, we will first examine their contribution to these difficult problems.

Petroleum

Petroleum has been an accessible, efficient, and economical hydrocarbon. It has helped power our planet, diversify economies, and in many cases, improve living conditions. In spite of this, the drawbacks started from the very moment it was found; its production, transportation and usage has progressively harmed our environment and our waters. From all of these, burning the fuel we manufacture from petroleum (the main reason for which it is processed) is an alarming problem.

Carbon monoxide and dioxide (CO, CO2), and sulfur dioxide (SO2) are the most common emissions originated in the production of petroleum-derived fuels; lead is also an air toxic produced when specific types of petroleum are burned. In a previous section, we discussed how the temperatures on Earth depend on balancing the electromagnetic radiation absorbed by our planet and the re-radiation of the not absorbed light. Some of this radiation, in the form of infrared rays, helps warm our planet; another part is released past our atmosphere. When petroleum is being processed, the emissions and byproducts tend to accumulate in the atmosphere and trap the infrared rays leading to the greenhouse effect. The windows in a greenhouse trap the heat inside; the same happens in the atmosphere as the "greenhouse gases" act as windows around our planet, trapping more heat inside. This has led to what scientists call Global Warming.

SO2 also causes acid rain. Sulfuric acid ($_2$ SO $_4$) forms when sulfur compounds in petroleum and its products react with water and atmospheric oxygen. This leads to precipitation with nitric and sulfuric acids. Although there is a natural-occurring acidic aspect in rain, rising levels can hurt crops and wildlife, destroy buildings, and cause respiratory illnesses and heart diseases in humans. [18]

A final consideration is oil spills which tend to create environmental and habitat problems. After the 2010 Gulf of Mexico oil spill, the New York Times published a multimedia series which claim that since 1990 more than 110 million gallons of petroleum and its products have been leaked throughout the extensive network of pipelines in the nation. Around fifty percent of these leaks had occurred in Texas, Oklahoma and Louisiana. [19] In spite of this, some authors disagree on the long-term impact of such occurrences on our planet's ecosystems. [20]

Natural Gas

It is claimed that using natural gas as fuel does not release as many emissions as any other hydrocarbon. [21] The natural gas industries have also taken many precautions to prevent or dispose of gas leaks by flaring or burning it at well sites instead of releasing methane into the atmosphere, even though this process still creates CO_2. Some of the main concerns about natural gas have to do with the impact its production will have in new areas where environment, wildlife and population are prone to be affected. The other area has to do with fracking. Fracking uses water for the mining process which is thought to diminish the available supply of water for nearby residents; at the same time, there are concerns about the pollution of underground water reservoirs since large amounts of wastewater are created in the process. Some people have also voiced their worries about earthquakes but there is no consensus about this aspect of fracking.

A shift from coal to natural gas does not eliminate the impact of fossil-fuel burning in the warming of the planet but it can be a desirable temporary step while cleaner alternatives become more accessible and inexpensive. At the same time, recent analysis and debates claim that the percentages of methane contribution to the greenhouse gases are larger than reported. [22]

Coal

Just like petroleum, coal and the availability of carbon allowed humanity to shift from wood burning, and the decimation of woods and forests, to an energy source less destructive. However, population growth and dependence on this hydrocarbon, especially for our addictive need to electricity, has brought its use to very dangerous levels.

The effects of coal extraction in the environment and atmosphere are devastating. Although coal-producing industries attempt to replant the sites, replace topsoil and return dirt and rock to the mountain tops and pits they mine, Greenpeace International reports that these projects' rate of success are very low, usually between 10-30 percent. [23] These sites never come to be what they once were. In the case of mine tunnels, many accidents have proven their instability and caused many deaths; moreover, miners breathing coal dust in these mines can easily develop black lung disease.

Coal-firing plants release about twice the CO_2 of oil and gas into the atmosphere, as well as SO2 and mercury (Hg); all of these add up to the greenhouse effect and global warming. [24] Industries have tried to handle these emissions more effectively by cleaning the coal after it is mined, or "scrubbing" it to clean it from sulfur before it goes through the smokestacks. Research is currently addressing how to separate CO_2 from the emissions, sequester it and later store it in a permanent underground site. [25]

Renewables

Consumption of renewable sources of energy has been slowly, but progressively increasing. With CO_2 in the atmosphere at its highest levels ever (and a strong likelihood of even higher levels very soon), the melting of polar ice, destructive weather-related events, and the rising of the average temperatures, world governments and leaders, environmentalists and industries, have been taking the lead in developing new technologies to make renewables more accessible and less costly.

An approach that keeps gaining momentum is the organization of local projects at the individual or cooperative levels that take advantage of the renewable energy sources at hand to power their communities. This enterprise spirit has already seen some successes in Willits, California; Toronto, Ontario; Burlington, Vermont; Gainesville, Florida; Newburyport, Massachusetts; and Wildpoldsried, Germany. [26]

As shown in the table above, energy consumption of renewable sources in the US has a presence and, year after year, there's a small but significant increase. These sources include biomass, hydropower, geothermal, wind and solar energy. This unit will only focus on solar and wind power.

Solar power

Photosynthesis has proved to be an effective process for harvesting the sun's energy for more than 2 billion years. The solar radiation that reaches the Earth does not only have to be only utilized by plants but can be, and has been, used to create heat and electricity. There are two ways of converting the Sun's light into electrical power: in photovoltaic devices (PVs) or "solar cells" sunlight is directly converted in electricity; and in Solar Thermal Power Plants, the concentrated solar energy heats a fluid to produce steam which in turn powers a generator; these can be found in California, Arizona and Nevada.

We can draw on solar energy passively as when buildings are designed to use most of the sun light; or actively, when PVs are used, or by installing panels that produce heat for solar domestic hot water (SDHW). [27] Solar energy output and devices do not pollute the air or emit CO_2; their impact on the environment is minimal when they are located on buildings. The main problems with this renewable energy is, as indicated previously, the unevenness with which the sunlight reaches the Earth's surface which means a large area is needed to collect energy at useful rates. A second concern relates to some toxic materials and chemicals employed in the manufacturing of PVs.

Wind power

Wind power is one the most rapidly growing technologies in the world of renewables. [28] It uses highly developed machines called turbines, gathered in "wind farms", to generate electricity. When wind turbines were originally utilized as early as 1891, they could only produce a few kilowatts (kW) of energy, able to power a couple of houses; now, technological improvements have made them able to generate electricity for whole communities. The new turbines can produce over 1.65 megawatts (MW) with blades measuring as long as the wingspan of a Boeing 747. [29] Turbines are becoming less expensive to make and, since they don't require fuel, generate solid waste, or use water, the world wind power capacity has been increasing double fold every three years. [30]

Some of the controversies that arise with wind power generation are similar to those related to solar energy: wind is not a constant energy, and wind farms need large areas for installing enough turbines to create sustainable rates of energy. They can also be perceived as an eyesore, and animal-right activists allege they kill birds (some researchers maintain that tall buildings kill even more birds). [31] A final argument is that when compared to the solar installation at home, solar energy is a more efficient renewable.

The development of the wind power industry has been especially strong in Europe, specifically Denmark. The Danish government and farm-based communities have been powerful advocates of energy independence financing and taking charge of their wind projects. In the US, Oklahoma has seen a sustained increase in their wind-energy production. It was reported in April of 2013 that the state had climbed to the fourth place in the nation with a wind power generation of 1,127 MW –Texas, first in the nation, generated 1,826 MW in the same period. [32]

Conservation

Regardless of the problems with nonrenewable and renewable sources of energy, the environment or our whole planet, something that we all can do right now is look at the energy consumption in our homes, and be proactive about its conservation.

There are more and more conversations, articles and books about how, in spite of the less expensive nonrenewables that we keep using, a gradual increase of renewables is desirable to save humankind. However, some energy specialists advocate for no development of new power sources of any kind because we tend to lack awareness of the amount of energy we consume and what we really need. [33] There are countless resources, in print and online, to educate us in calculating our energy consumption and reducing our carbon footprint at the places where we can truly do something about: our own communities.

It is, therefore, a matter of curiosity and responsibility to see how our homes can be energy-sufficient without sacrificing comfort and, even more significantly, pay attention to how we use our vehicles and the available alternatives for less fossil fuel-consumption engines. At the end, the solution to our energy needs and sources may require a combination of solutions instead of an all-encompassing resolution for all.

Activities and Strategies

For this unit, the students will have an Energy Journal in which they will enter key vocabulary, concepts and ideas; they will also be guided to answer questions, draw and/or glue images about the topics we discuss, and prepare summaries and short essays. The journal, altogether with the students' participation, and doing the demonstrations, will be the basis for their self-evaluation and teacher's assessments.

Initially, I want students to gain awareness about the current levels of energy usage in their own homes. To that effect, I gave the incoming fifth graders a Home Energy Usage Chart at the end of the previous school year. This document lists common appliances used at home, their typical wattage, the average monthly kWh (kilowatt-hour), and the typical monthly cost. During the summer months, they would have selected from the chart those appliances present in their home and created their own table; this new table includes the monthly and yearly costs of their appliances. They were also instructed to find the average cost per day/appliance to then multiply the result by the number of vacation days; after these calculations, they will have a final number which represents energy consumption per appliance while they were at home.

At the beginning of the school year, the students will have their own Home Energy Usage Chart which will be made from their observations and data collection done during the summer months. We will establish several conclusions from this first inquiry such as that without energy there wouldn't be much going on in their homes, and that energy has a daily cost. We will also study the following units: watts (W), kilowatts (kW), and kilowatt-hour (kWh).

Energy: definition, sources and storage

In this section, it is important for students to conceptualize energy. We will have a brainstorming session, followed by discussion and questions; they will also be encouraged to find different forms of energy around them. I will present the example of a car and where the power to run it comes from. This will allow me to guide the discussion to sources of energy, and the terms renewable and nonrenewable. We will then take the Energy Quiz in the EIA Energy Kids website (this quiz can be taken at the end of the unit to show students' gains and/or needs.) After the quiz, they will be given cards with sources of energy and, in small groups, will classify them in renewables and nonrenewables. It is important that students differentiate between sources of energy and types of energy (heat, chemical, electrical, mechanical, light, and sound.) A discussion and some examples will clarify the distinction.

In a later session, through a series of short investigations, students deduce that energy is stored, transforms and that it can be carried from one place to another by electric current, waves or moving objects. Depending on the availability of resources, teachers can have stations or demonstrate for the whole class, using student volunteers. In the first investigation, students learn that potential energy stored in batteries can make things work (flashlight, motor, toy, cell phone, etc.) In the second one, students perform some work and reason that their potential energy comes from the food they eat; in the third investigation, a candle is lit and the discussion is led so students find out that wax is a type of fuel that produces heat and light; and, in a final investigation students rub their hands together, create heat and learn about friction. From these activities, the teacher can also guide students to understand kinetic energy as energy moving to an active mode from a resting or potential mode. This session should end with students understanding the concept that energy is the capacity to do work and see this occurring in all living things.

Later, I will read the book "Pass the Energy, Please" which shows how the food chain depends on plants, and energy accumulated in them. I want to establish that initial connection about energy, sun and plants (apart from energy's interdependence with every living organism) for the next discussion on fossil fuels.

Fossil Fuels

A second book I will read aloud is "Why Should I Save Energy?". The story presents what happens when there is no electricity; this gives the narrator an opportunity to explain how electricity is created from fossil fuels to later propose the scenario of a world where fuel runs out; a logical conclusion about the need to save electricity and fuels ensues. We will then discuss petroleum, carbon and natural gas.

The discussion about fossil fuels will make a connection with the first book we read which links plants to energy. We will briefly discuss photosynthesis, watch a video and have a geologist guest talk to us about fossil fuels, the new technologies and discoveries (liquefied gas, tar sands oil, shale gas, and oil shale) and the eventual disappearance of these fuels. The third literature connection will be "Living Sunlight" which emphasizes the concept of solar light helping to produce the energy present in every living being.

During the next session, we will discuss the impact of fossil fuels in the environment. Several demonstrations follow in which students will strip-mine a chocolate cookie, clean an oil spill, and look at carbon particles on the bottom of a glass after putting it over a flame. For the first one, students divided in groups will use toothpicks to try to remove the chocolate chips with as little damage as possible to the whole cookie. They cannot use their hands or any other utensil. I will encourage some brainstorming about the best technique before actually doing the work. After all the groups have mined their cookie, students will discuss their results, and the condition of their "site", the cookie. From here, another discussion will ensue about coal mining and the environment. For the second activity, cleaning the oil spill, students create a habitat in a tub with water. (I will ask them to bring some things from home for their group habitat.) I will pour 1 tablespoon of oil into the habitat, and they will brainstorm the best way to try to clean it from the spill. However, before cleaning, I want them to take a few minutes to observe any impact the oil can be producing in their habitat. After the activity, I will guide the students to discuss oil spills in the world; the article from The New York Times referenced above in the section on Petroleum has a detailed map online with oil spills that I will show the class. The last activity here is about carbon in the atmosphere. I will light a candle and have the students place a jar or glass above the flame until soot forms. I will guide them to see the connections between the first session when they found out wax was a type of fuel to explain now how most candles are usually made with paraffin, which is derived from oil. The candle then is a type of hydrocarbon and burns like any other hydrocarbon, including all fossil fuels.

We will later watch and discuss the video "Fossil Fuels" from Schlessinger Media, and examine a few graphs about total energy consumption in the US and the world by source types. Most of these graphs come from the Energy Kids web pages in the US Energy Information Administration website.

The environment, pollution and global warming

From the previous session, the students will have acquired enough information to now move on to pollutants and global warming. We will initially focus on our relationship to the environment and the need to keep it clean to safeguard life on Earth. Our discussion will start with a brainstorming session on what things/activities students think pollute the environment and later rank those items from the most to the least contribution. A common list of pollutants should have items that can be placed in a broader classification of air, water and land pollution. Towards the end of this activity, students will be able to trace the biggest impacts of pollutants in our environment to fossil-fuel related activities.

Right after, we will study 2 graphs: one from econbrowser.com that shows CO_2 emissions by fossil fuel; the second one from earth-policy.org which shows the top 5 countries with the most carbon emissions. Analysis and conclusions will point out that carbon emissions are slightly diminishing in the US but that globally they are still increasing and that coal and petroleum consumption is lowering but natural gas consumption is rising. In a next session, we will spend some time studying and discussing the interactive map in the Breathing Earth website: this world map displays the amount of CO_2 being released in real time by every country in the world.

We will continue by watching a video about the greenhouse effect and global warming from You Tube. From this video, students will understand that there is a natural, desired greenhouse effect that, however, has been exacerbate by our energy choices. Further discussion will be led to bring students' awareness to the potential for catastrophes if we continue such a path. We will come back to the importance of energy and I will guide them to arrive at the conclusion that, as a country, we need to rely on the energetic resources readily available, and closer to our communities. We will discuss how sustainable sources of energy keep us competitive in the world market while also ensuring the survival of our planet. A guest speaker from Sustainable Tulsa will join us to present and discuss renewables, as well as any local or state initiative regarding new and cleaner sources of energy.

Renewables

For the next sessions, we will discuss solar and wind energy. The solar energy investigations will deal with tracking shadows, measuring temperatures in the sun and in the shade, observing the rate at which some earth materials (sand, soil, etc.) gain heat, and designing a solar water heater; here, we will check the effects of color on heat absorption and surface area. All these activities come from the Full Option Science System (FOSS); in the Teacher Resources section, I include a website with videos about these activities that can be recreated even if this kit is not available. We will end with a discussion on homes powered with solar energy and watching the video "Megastructures: Sun Engine" from the National Geographic Digital Media.

Our final focus is on wind energy since Oklahoma has increased the installation of wind turbines, making them very visible in the state's wind corridor, and wind energy production has been substantially increasing in the last ten years. There is a short video about Oklahoma wind power that I will show. I have two short books that I will read to the students about community-driven wind initiatives in the island of Samsø in Denmark ("Energy Island: how one community harnessed the wind and changed their world") and in the African country of Malawi ("The Boy Who Harnessed the Wind").

This unit finishes with designing windmills (one per study group) and later testing them to determine power output; that is, we will calculate work plus power output in watts. A video about this activity can be found in the Hila Science Videos webpage and in You Tube.

Conservation

We will end by discussing conservation as one of the strategies we can do right away to save on energy. I will invite personnel from Tulsa Public Schools to the discussion since, in the month of June of 2013, our school district made headline news because of the energy savings during the school year 2011-2012. Right after, we will take the Energy Quiz in the EIA Energy Kids website and compare with the one students took at the beginning of the unit.

As an epilogue activity, students will reexamine their energy consumption charts and discuss what conservation initiatives they can start right away at home. We will write them down and keep them posted in the classroom, and throughout the year we will evaluate our progress. If new ideas arise, we will include them, and if some prove inefficient and impractical at the moment, they will be deleted.

A second major goal is to make this a cross-curricular unit. Thus, in Social Studies/History when we study the British Colonies in the New World, we will look at energy and the survival of the colony of Jamestown; in Language Arts, I will use the fiction and non-fiction books of the unit to teach reading strategies and comprehension; and in writing, I will address essay development over time while the students keep working on their Energy Journals. I will also integrate our Math objectives throughout in computation, data collection and graphing while we are doing the Science activities.

Teacher Resources

Literature:

"Pass the Energy, Please", by Barbara S. McKinney and Chad Wallace

Narrated as a rhyming story, the authors present rich images and text about different food chains in which plants become the hero on the efficient task of passing energy. There is also a Teacher's Guide called "Nature's Food Chains."

"Why Should I Save Energy?" by J. Green and Mike Gordon

From the premise that there is no electricity, the characters explain how electrical power is created from fossil fuel; it also details what would happen if we ran out of fuels, and how to save energy.

"Living Sunlight: How Plants Bring the Earth to Life", by Molly Bang and Penny Chisholm

This powerful story and its visuals help us see clearly how we all share a same unique source of energy: the Sun.

"Energy Island", by A. Drummond

Engaging illustrations help narrate what happened in Samsø, Denmark where the citizens decided to harness the wind power; panels in some pages in kid-friendly language describe nonrenewable and renewable energy, global warming and wind energy.

"The Boy Who Harnessed the Wind", by W. Kamkwamba and Bryan Mealer

Children's story about real life inventor William Kamkwamba who, as a 14-year-old in Malawi, built a wind tower to bring electricity to his home.

Internet:

Home Energy Usage Chart:

https://www.psnh.com/downloads/ResidentialEnergyUsageChart.pdf?id=4294968497&dl=t

EIA Quiz:

http://www.eia.gov/kids/energy.cfm?page=quiz

FOSS -Solar Kit, videos:

http://archive.fossweb.com/modules3-6/SolarEnergy/index.html

Carbon Emissions Graphs:

http://www.earth-policy.org/indicators/C52

http://www.econbrowser.com/archives/2013/03/declining_us_ca.html

Greenhouse effect and global warming

http://www.youtube.com/watch?v=dP-tg4atr5M&list=PL56E926C9E40B9463

"Energy Island":

http://www.youtube.com/watch?v=baeGMF-z0fM

Making a windmill:

http://hilaroad.com/video/windmill.html

http://www.youtube.com/watch?v=F3bZzOyMhKI&gl=CA

Notes

1. Gillis, Montaigne, 2013

2. Yergin, 2012

3. Fenn, 1982; pp. 1 – 4

4. McElroy, 2010; Stein & Powers, 2011

5. Stein & Powers, 2001; p. 8

6. Yergin, 2012, p. 245

7. Mann, 2013

8. Stein & Powers, 2001; p. 4

9. Walker, 1992; p. 122

10. EIA, 2013

11. Saleri, 2008; Muller, 2012; Yergin, 2012

12. Yegrin, 2012, pp. 230 - 243

13. Freudenrich & Strickland, 2013

14. EIA, 2013

15. Mann, 2013; Yergin, 2012, p. 329

16. Stein & Powers, 2001, p. 80

17. Yergin, 2012, p. 403

18. Wilford, 1989

19. The New York Times, 2011

20. Muller, 2012; Yergin, 2012

21. Muller, 2012; Stein & Powers, 2001; Yergin, 2012

22. Gerhardt, 2013

23. Greenpeace International

24. Muller, 2012; Pahl, 2007

25. Sarewitz, 2013; Yergin, 2012

26. Pahl, 2007; Pahl, 2012

27. Pahl, 2007, p. 20

28. Yergin, 2012, pp. 540 - 544

29. Pahl, 2007, p. 21

30. Muller, 2012, p. 164

31. Muller, 2012, p. 166

32. Walton, 2013

33. Muller, 2012, p. 166

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