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The Pros and Cons of Energy: An Investigation of Energy Sources and Human Impact

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Introduction and Rationale

"Solving climate change is more important for our future than tackling many other worthwhile causes, because so many issues – poverty, disease, immigration politics – cannot improve if climate change worsens." *(Goldstein-Rose and Kitchen 2020)*

The topic of renewable and clean energy is of increasing importance to everyone on this planet. We have until about the year 2050 to fix our relationship with fossil fuels, reduce atmospheric greenhouse gas emissions, create a new infrastructure, and find new ways to meet our energy needs. The teenagers in my classroom today will be the adults in the future making decisions about energy usage, working in the STEM careers that will be creating solutions for our energy crisis, and will also be most affected by the changes necessary for a sustainable future. They will also be affected by the consequences of failing to act before it is too late. We are already experiencing stronger storms, increased flooding, and rising global temperatures. It is important that they gain a basic knowledge of what our current energy options are and what the future of human energy consumption will look like. In many industrialized and developing countries, this will mean creating new infrastructure at an extremely fast pace. Our new infrastructure will include many types of renewable and clean energy sources working together to meet our energy needs. Currently, there isn't one type of renewable or clean energy that can meet all of our needs. There are different factors related to each energy source that affect how it works and how it can be used.

Students will investigate the environmental and commercial benefits and drawbacks of different energy sources. Additionally, students will investigate human consumption of energy and the effects of human activities on the environment including, but not limited to, climate change. Students will engage in research about fossil fuels, biomass, wind, solar, hydroelectric, geothermal, and nuclear power. Students will be placed into collaborative groups. Each group will be assigned one type of energy source to research. While researching they will complete a graphic organizer to capture the information they discover. They will use the research and graphic organizer to create a presentation about how the energy source works, how it is used in Virginia (our home state), how energy sources are currently affecting us (the pros and cons), and how it will be used in the future. Students will then engage in hands-on demonstrations of renewable energy types to demonstrate how renewable energy can be used to meet our needs.

Demographics

Thomas H. Henderson Middle School is located on the north side of Richmond, Virginia. It is one of eight schools in Richmond City Public Schools. It is a title one school where the student population is economically disadvantaged. We have a few middle-class families and very few are not native to America. I teach all of the 8th grade students that attend Henderson Middle School. There have a range of cognitive abilities from gifted to students with an individualized education plan (IEP). I do not teach students with severe disabilities. Most of my students have a basic knowledge of scientific topics. Some students have advanced knowledge and are able to explain complex scientific ideas and others struggle to write a complete sentence to communicate their ideas.

Content Objectives

The standards that this unit will address come from the Virginia Standards of Learning (SOLs). Virginia chose not to adopt the Common Core or Next Generation Science Standards.

The primary standards covered in this unit are ENV.7 which ask students to investigate and understand Earth's resources are finite by exploring certain resources that are nonrenewable because it can take up to millions of years to replenish. Additionally, students are asked to investigate the environmental and commercial benefits and drawbacks of different energy sources, to include fossil fuels, biomass, wind, solar, geothermal, hydroelectric, and nuclear power. This unit will also cover ENV.8 which asks students to investigate how human consumption of energy will affect the future availability of nonrenewable resources and how the effects of natural and human-caused activities may either contribute to or challenge an ecologically sustainable environment. This unit will also connect to standards that cover human behaviors that impact the environment, climate change and possible solutions for the future.

Background Information

This section contains content knowledge about the different types of energy sources.

Fossil Fuels

"Currently, over 80% of the energy used by mankind comes from fossil fuels." *(Department of Energy 2024)* While many enjoy the benefits of fossil fuels, not everyone uses them. Unfortunately, the waste products from the combustion of fossil fuels affects everyone on the planet. For example, burning fossil fuels contribute 30 Gt of carbon dioxide released into the atmosphere each year and this has triggered climate change. Additionally, the transportation and mining of fossil fuels in the ocean have had leaks that have killed ocean wildlife and affected the water quality. Fossil fuels are relatively cheap, and many rely on them to meet their energy needs. Fossil fuels are very popular for developed, and developing, countries because they are

accessible all over the world, they are efficient, make fuel for transportation, are relatively cheap, and can be converted from solid to liquid or gas fairly easily. Fossil fuels also have an established infrastructure and industry.

In 1855, the Silliman Report disclosed the findings of Benjamin Silliman, Jr. from his experiments with petroleum. These experiments were performed as a result of the energy crisis of that time period of using whale oil in lamps to light homes at night. The whale population was being depleted and a solution was needed. Benjamin Silliman Jr. found that petroleum can be distilled into different substances. One of those substances was kerosene and the other was gasoline. The kerosene was a great substitute for the whale oil and at that time, the gasoline was discarded. Unfortunately, it was usually thrown away in a river which was disastrous for the environment. Thankfully, scientists found a use for gasoline. Gasoline has a lot of stored energy and is easily portable. Instead of throwing it in a river, gasoline is a great way to fuel the combustion engine of our vehicles. The conclusion of Silliman's experiments resulted in the start of the petroleum age and our dependence on fossil fuels for our energy needs. *(Reuben A. Holden, Secretary of Yale University, Records (RU 19). Manuscripts and Archives, Yale University Library.).*

Fossil fuels like oil, coal, and natural gas are the remains of prehistoric plants and animals that died and were buried under sediments millions of years ago. Depending on the type of plant or animal, the temperature, the pressure, and how long it was buried determined the type of fossil fuel created. These resources are mined from deep underground and burned to produce electricity or refined to be made into fuel for transportation or heating. *(Department of Energy 2024)* After these resources are mined, they are processed for our energy needs. For example, "In conventional power plants, pulverized coal is burned in a boiler, where heat vaporizes water in steam tubes. The resulting steam turns the blades of a turbine, and the mechanical energy of the turbine is converted to electricity by a generator. Waste gases produced in the boiler during combustion – among them, SO_2, NO_x and CO_2 – flow from the boiler to a particulate removal device and then to the stack and the air." *(Fulkerson, William, Roddie R. Judkins, and Manoj K. Sanghvi. "Energy from Fossil Fuels." Scientific American 263, no. 3 (1990): 128-35. http://www.jstor.org/stable/24996937.)* The combustion of fossil fuels releases carbon dioxide into the atmosphere and is causing global warming because CO_2 is one of the major contributing gasses in the greenhouse effect. Carbon dioxide traps heat from the sun that would have escaped back into space. We need some CO_2 to stabilize our temperature, but too much CO_2 in the atmosphere traps more heat than we need causing the global temperature to rise.

Solar

We can use the sun's energy to produce electricity. Solar panels can be used to harvest energy from the sun. "Solar energy is an endless source of energy, which is ecologically clean and is not considered harmful." *(Jakhongir Turakul Ugli 2019)* The sun's energy has been used by humans as early as the 7th century B.C. to light fires by reflecting the sun's rays onto shiny objects. The Greeks and Romans manipulated mirrors to focus the sun's rays to light torches. In 1839, a French physicist named Edmond Becquerel discovered the photovoltaic (PV) effect while performing an experiment. He exposed a cell that was connected to metal electrodes and submersed in a conducting solution to a light source and noted that it produced more electricity. In 1954, PV technology was enhanced when Daryl Chapin, Calvin Fuller, and Gerald Pearson developed the silicon PV cell at Bell Labs. The first PV cell capable of converting the sun's energy into electricity to power everyday equipment was created. Solar panels use a semiconductor, like silicon, encased in glass. The panel is exposed to the sun. The photons of sunlight cause an electron to be released and produce an electric charge. The charge creates an electric current, direct current (DC), which is captured by wires inside the panel. The DC is then converted to alternating current (AC) by an inverter. AC is the type of

current we use to power our electric devices. *(National Grid 2023b)*

At any given time on the planet, we are using 18 terawatts of energy. If we could capture one hour of the sun's energy striking the planet at any given time, then we could power the planet for one year. However, capturing and storing the sun's energy isn't an easy task. Solar panels can be expensive to produce and require several factors to operate at peak performance. Solar panels need land or space for installation, to be cleaned regularly, and angled towards the sun to receive direct sunlight. The sun moves across our sky and doesn't shine at night and is less efficient on a cloudy day. Therefore, a system will need to be created to store the energy captured to be used when demand is high. In areas with a large installation of PV panels, such as Southern California, much of the energy produced by solar panels during the day can't be used because there isn't a high demand for the electricity (See Figure 1). Our electricity demand increases dramatically in the evening hours just before sun set and rises sharply through the evening and into the night. The demand decreases as we approach midnight and increases again when we wake up in the morning.

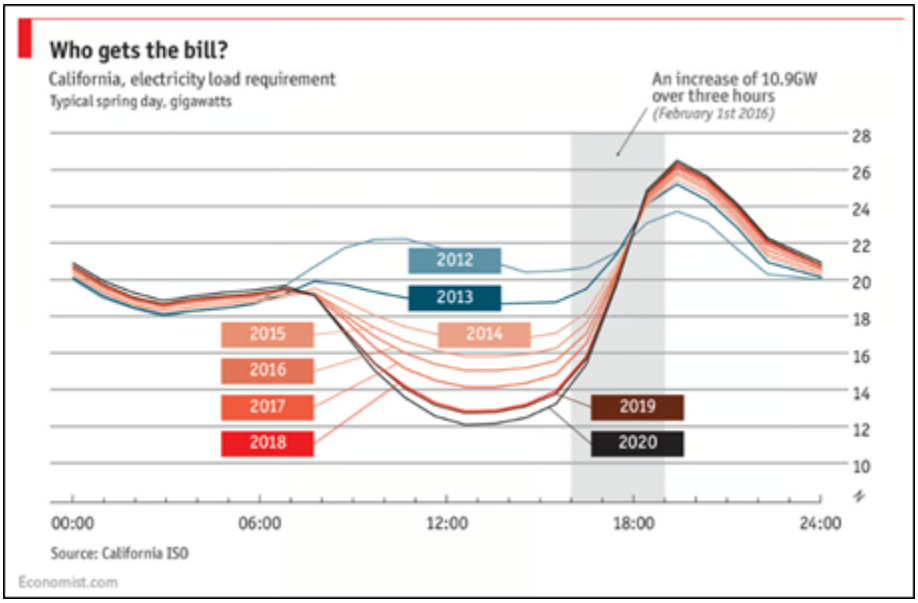

Figure 1 shows the energy demand in California on a typical spring day from 2012 – 2020. Source: https://www.economist.com/graphic-detail/2018/03/28/what-a-ten-year-old-duck-can-teach-us-about-electricity-demand

Using the sun's energy is not only limited to solar panels. The sun can be used for thermal heat and cooking. A solar oven is a device that can be created in a variety of ways. Using household materials, you can create a small solar oven to cook simple items. Larger solar ovens can be created to cook larger items. There are many communities around the world that use the sun to cook their food. Some people use them when they are camping and do not have access to electricity.

Wind

"Man has harnessed the energy in wind for thousands of years, both for sailing boats and powering wind mills at land." *(Jaber 2014)* As far back as 5,000 B.C., sail boats used the wind to navigate the Nile River in Egypt. Around 200 B.C., wind was used to pump water in China and grind grain in the Middle East. This technology has continued to grow, expand, and improve over time. Today, wind power is one of the leading solutions to our energy crisis.[1]

Wind energy generation is clean and renewable. It requires no fuel and has zero harmful emissions. Unfortunately, it can't be used in many places due to its visual obstruction and threat to wildlife, and the wind doesn't blow all the time. Wind turbines are usually white or pale grey to make them blend in with their environment. Some places require additional markings on the ends of the blades for visibility. There has been discussion about painting them green to help them blend in with the environment better.[2]

Wind energy can be captured on land or offshore. The potential for this resource is rapidly expanding. Offshore turbines are placed out in the ocean. On land, wind turbines are placed in fields or in rural areas where large buildings and obstructions don't interrupt air flow. The very first wind turbine was created by Professor James Blyth in Scotland in 1887. It was ten meters high and had a sail cloth. The first wind farm opened in the United States in 1980 in New Hampshire. The wind industry has continued to grow and improve over time. Wind turbines vary in size and can be adapted for personal use or connected together to form a wind farm. Each wind turbine consists of two or three blades, a gear box called a nacelle and a shaft. When a gentle breeze or gust of wind makes the blades spin, electricity is generated. The kinetic energy generated from the rotation of the blades is transferred to the gear box and generator, which creates an electric charge. Most wind turbines operate between seven miles per hour (mph) and 56 mph and maximum efficiency is usually between 18 mph and 27 mph.[3]

Unfortunately, wind turbines have had a negative effect on the environments where they are placed. There have been habitat losses and disruption. Additionally, birds have collided with them and died. However, wind power's impact on bird populations is relatively small when compared to the number of birds killed by cats and their collisions with high rise buildings. Additionally, in order for wind turbines to work, they need to be placed in a windy location. Not every location is a viable place for the implementation of a wind turbine to provide electricity. Wind energy is a type of solar energy. As the sun heats up the Earth, land and water heat at different rates. The differences in temperature create a convection current, causing the wind to blow. Also, the wind is intermittent and does blow all the time.[3]

Hydroelectric

Hydroelectric energy production is the most cost effective and is unlimited as long as the source remains available. It accounts for about 16% of energy production in the world today. *(Bagher et al. 2015)* Hydropower is a renewable energy source that uses a dam to alter the flow of a river to generate electricity. The hydropower source requires a constant replenishing from the water cycle. Electricity is generated by flowing water that has a change in elevation. The greater the elevation, the greater the kinetic energy of the flowing water and the greater the potential the create electricity. Flowing water turns turbines inside a generator that creates an electric current.[3] Unfortunately, the building of dams has a negative effect on the surrounding environment and a dam failure can be catastrophic to the humans and animals that live near it. There have been numerous dam failures that have occurred throughout history. However, with proper maintenance, dam failures can be avoided.

Humans have been using water to perform work for thousands of years. The Greeks used it to grind wheat to make flour. In 1881, a water turbine in a flour mill provided street lighting at Niagara Falls, New York using direct current. In 1893, the Redland Power Plant used water wheels and a three-phase generator to create power. Over the years, a number of innovations have allowed hydropower to become an important part of the renewable energy options available to us. For example, alternating current allows the power generated by a water turbine to be transmitted across longer distances.[4]

The most famous source in the United States is the Hoover Dam built in 1936 on the border of Nevada and Arizona on the Colorado River. Hydropower accounts for about 6.2% of total electricity generation in the United States. All but two states (Delaware and Mississippi) use hydropower as a part of their electricity plan. The use of water generated power varies from state-to-state. For example, in 2020, the state of Washington used hydropower for about 66% of their electricity needs. Additionally, states like Washington, Idaho, and Oregon have lower energy costs than the rest of the country due to their use of hydroelectric power. The initial cost of installing a hydropower facility can be high, but that evens out over time. Hydropower has a long-life span and maintenance cost are relatively small. This results in hydropower being much more cost effective than other energy sources. Hydropower stations vary in size from Hoover Dam sized to tiny personal use. Not all hydropower comes from dams. Some use diversions or run-of-river facilities like an irrigation ditch.[4]

Geothermal

Geothermal energy is produced by heat conduction. Water transports the energy to the surface for utilization and then must be recharged. However, those sources can take a long time to recover. So, geothermal energy may not be renewable in most places. Geothermal energy can also be extracted from hot dry rock, but this is still in the experimental stages*. (Stefansson, V. (2000, May). The renewability of Geothermal Energy. In Proceedings of the World Geothermal Congress 2000 (pp. 883-888).*

Geothermal heat pumps take advantage of the relatively constant temperature below the Earth's surface at about 30 feet below ground where the temperature is typically between 50 ◦ F (10 ◦ C) and 59 ◦ F (15 ◦ C). So, the soil temperatures are usually higher than the air temperatures in the winter and cooler than the air in the summertime. Geothermal heat pumps exchange temperatures, efficiently heating homes in the winter and cooling them in the summer (See Figure 2). This method of heating and cooling is energy-efficient, environmentally clean, and cost-effective. It can be used in all types of buildings, not just homes.[4]

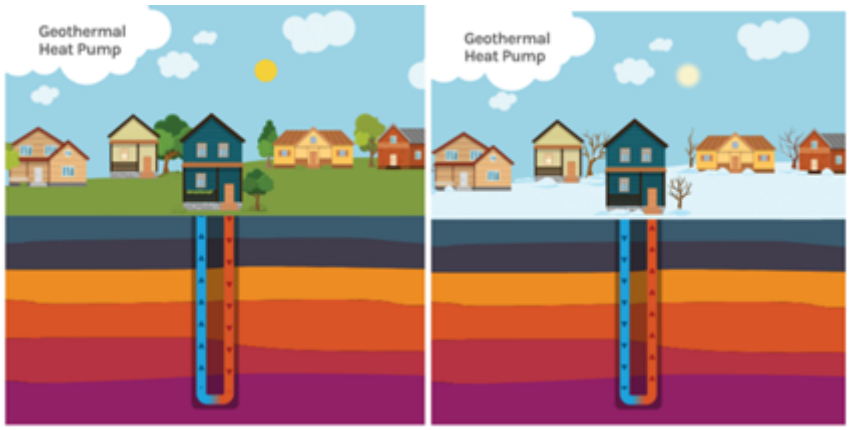

Figure 2: A geothermal heat pump extracts heat from the home in the summer and pumps heat into the home in the winter.[6]

There are hot water reservoirs all over the world. This water can be found at the surface, like a hot spring, or deeper down. The temperatures of these waters can range from 300 ◦ F to 700 ◦ F. The steam produced from these hot waters can be used to spin a turbine and create electricity.[5]

Currently, California has 43 geothermal plants with plans to build more. In Boise, Idaho, 92 of the biggest

buildings in the city use geothermal heating. "A 2019 U.S. Department of Energy report, *GeoVision: Harnessing the Heat Beneath Our Feet*, says 'generating electricity through geothermal methods could increase 26-fold by 2050, providing 8.5% of the United States' electricity, as well as direct heat."[7]

Biomass

Biomass is a renewable energy source. It has stored energy from the sun that is produced by plants through photosynthesis. It can be burned directly for heat, like burning a log in a firepit. It can also be converted to a liquid or gas. There are many different places to find a biomass source. For example: paper, corn, vegetable oil, animal fats, soybeans, sugar cane, algae, cotton, food scraps, human and animal waste (See Figure 3). Almost anything that benefits from photosynthesis has stored energy that can be converted to biomass through various processes.[6]

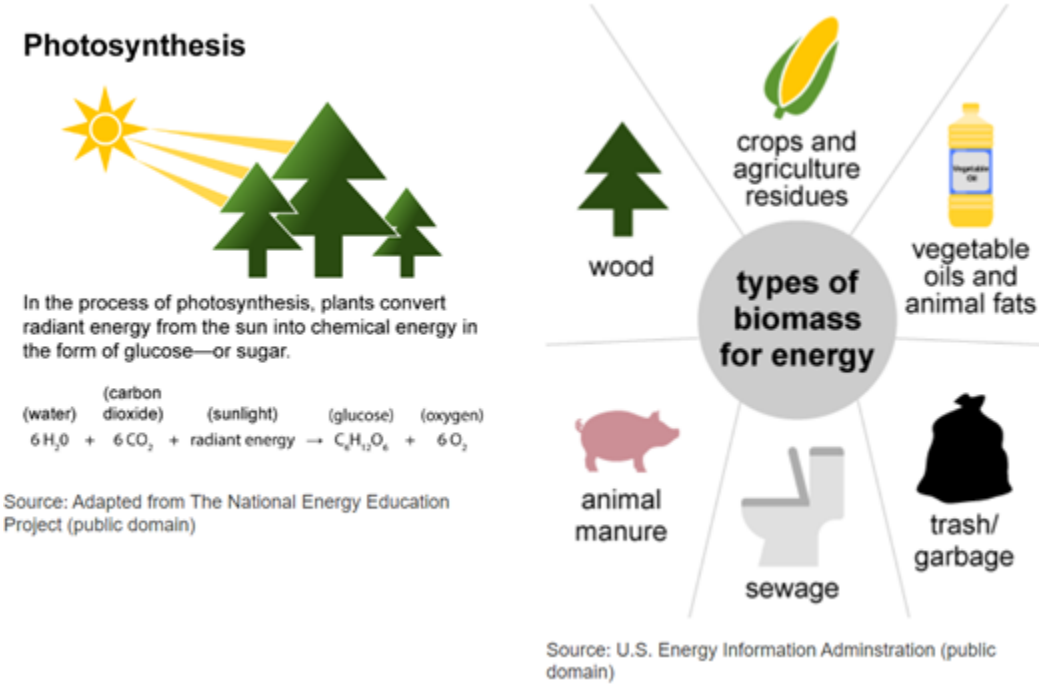

Figure 3: Photosynthesis is explained and examples of biomass are shown.

"Biomass was the largest source of energy in the United States up until its peak in 1870, when 70% of energy came from wood. … Coal and later petroleum, quickly replaced wood as the leading source of energy." There is a debate about whether or not biomass energy is carbon neutral. Environmentalists are concerned that it is not clean energy.[8]

Biofuels are created from biological materials like plants, animals, wastes and microorganisms. We are most familiar with wood as a biofuel burned for heat and cooking. Biofuels can be solid, gaseous, or liquid. "Biofuels are everlasting and renewable resource because they are incessantly refilled." *(Datta, Hossain, and Roy 2019)* There are many different types of biofuels. We can use corn to produce ethanol to power our cars. Unfortunately, this may have a negative effect on food prices. Using corn to make fuel instead of feeding people can drive up the price. Another way that biomass is used as an energy source is converting vegetable oil into biodiesel. If starting with used vegetable oil, first strain it to remove any left-over food pieces. Next, the process of transesterification converts fats and oils into biodiesel and glycerin. Using base ten ratios, if you were to take 100 pounds of oil and add 10 pounds of a short-chain alcohol (methanol) with a catalyst like

sodium hydroxide (or potassium hydroxide). Dissolve the sodium hydroxide into the methanol and agitate. Then add them to the vegetable oil and continue to agitate. Allow the mixture to sit overnight so that they separate into biodiesel and glycerin. The glycerin will settle to the bottom and the biodiesel can be poured off the top. Using our base 10 ratios, this will result in 100 pounds of biodiesel and 10 pounds of glycerin.[7]

Nuclear

Nuclear energy is clean energy but has an unfavorable waste product. It can be costly to build a nuclear power plant and currently they operate for only about 30 years. Additionally, uranium is not an unlimited resource, and the increase usage of nuclear energy may deplete the resource. "Nuclear power plants have generated about 20% of the United States' electricity since 1990"[8] The United States uses nuclear power more than any other country. There are 28 states that use nuclear power, operating 54 nuclear power plants.

The basic parts of a nuclear power plant consist of a reactor where the nuclear fission takes place. There can be as few as one reactor and up to six reactors. The electricity is generated in the machine room from steam that powers a generator. The electricity that has been generated is transported and/or removed through the outlet power lines. Lastly, the cooling tower is located near a large body of water and is used for cooling the steam back to water.[9]

Nuclear power uses heat made from atomic fission to boil water and produce pressurized steam. The steam is routed to spin turbine blades attached to a generator to produce electricity. Nuclear fission splits atoms when a neutron smashes into a larger atom causing excitement and the atoms split into smaller atoms. Extra neutrons are also released causing a chain reaction. When atoms split, a very large amount of energy is released.[10]

Nuclear reactors use small uranium pellets placed in metal tubes. The tubes are immersed in water forming a circuit. The water heats to about 320 ◦ C and kept under pressure to remain a liquid. This hot water is used in a steam generator to drive steam turbines and turn a generator creating an electric current. The resulting electricity can be as much as 400,000 volts and transported to the power grid. The steam from the generator has to be cooled and transformed back into water. A condenser uses cold water from the sea, a river, or cooled in an air-tower. This is why many nuclear power plants are located near a large water source. Nuclear power has no harmful emissions into the atmosphere.[11]

There are different types of nuclear reactors. The pressurized water reactor is the one I just explained. Eighty percent of the world's nuclear power plants use this type of nuclear reactor. They have an excellent safety record. Twenty-two percent of the world's nuclear reactors are boiling water reactors. These reactors do not have a secondary cooling circuit. The steam is led directly to the turbines. This type of reactor is more efficient and use less water. Heavy water reactors use a pressurized heat transfer fluid and a heavy hydrogen isotope known as deuterium. Fast neutron reactors use a closed fuel cycle that burns plutonium and reduces the amount of long-living radioactive waste. Gas-cooled reactors use helium to transport heat and are used in smaller power plants. There are new technologies being researched for smaller adaptations of nuclear power. These smaller reactors have improved safety and more resistant to nuclear accidents. They can also use fuel more efficiently and reduce the amount of radioactive waste.[11]

Unfortunately, there have been nuclear disasters like Three Mile Island in Pennsylvania in 1979, Chernobyl in Ukraine in 1986, and Fukushima in Japan in 2011. All of these resulted in radioactive material being released in the environment. Events such as these make people wary of nuclear power as an energy source.

Additionally, the radioactive waste and used reactor fuel can remain radioactive and dangerous to humans for thousands of years. There must be a commitment to the proper handling, transportation, storage and disposal of these waste products to protect human health and the environment. Currently, there is no long-term solution that can guarantee long-time safety.

Teaching Strategies

Home-School Connection

Students will use an energy survey of their home to estimate their carbon footprint. We will use this as a comparison point and build background knowledge of human consumption of energy. Making connections to real-life experiences serve to help students become engaged in the learning that will take place.

Collaborative Groups

Students will work in groups to complete the research of an energy source, complete a graphic organizer, and create a Google Slides presentation. They will also present in front of the class with their group. Collaborative groups will teach them to work with their peers and develop their social skills like active listening, empathy and respect. Presenting in their groups will help develop their oral communication skills, self-esteem, and leadership skills.

Research Project

Research projects help develop the skills needed to discern reliable sources. They will also use critical thinking and learn how to organize information. Students will be guided in the sites they visit to collect information. They will discern the types of information they are reading and will learn to cite their sources.

Graphic Organizers

Using a graphic organizer will help the students organize the information they find. They will also use it to create the slides for their presentations. Additionally, when each group is presenting, the students that are observing will be required to fill out a graphic organizer to keep them engaged in the presentation and hold them accountable for the information that is being presented.

Peer Teaching

The presentations delivered by the students to their peers will give them a new perspective to learn from. Students enjoy learning from their peers. Student engagement increases when they have opportunities to learn about a new topic from their peers. The students presenting are more likely to retain the information they learn because they will also be saying it out loud.

Guest Speaker

Inviting community members to the classroom to share their knowledge is beneficial to the learning that is taking place. An industry expert may offer a new perspective and can answer questions that the students may have. It also exposes students to different career opportunities that will be available to them in the

future. In this unit, it is suggested to invite a school facilities representative to discuss how the school system makes efforts to be environmentally efficient. A representative from the local power company could also be invited to speak about how changes are being made to the power grid to include renewable energy sources. Additionally, a state or local official could be invited to speak about how the government makes policies that contribute to a change in our energy supply.

Google Slides/PowerPoint Presentations

Google Slides and PowerPoint Presentations offer a visual representation of information to be presented to students. Many students enjoy being creative and making these presentations is a way to express that creativity. Students can engage their peers by including pictures and videos in the presentations to expand on their knowledge.

Hands-On Activities

Students learn by doing. The hands-on experiences that are included in the unit offer a demonstration of the energy source they are learning about. It also creates a shared core memory that I can refer to in future learning. It can also be a launching pad for future discovery by the student. For example, the students can take home their solar ovens after they make them in the classroom. They can show someone at home how it works, and it may activate their curiosity to learn more. Additionally, hands-on activities increase student engagement and offer an entry point to an academic topic they may not have had interest in previously. Hands-on activities also allow learning from real life experience and improve retention of information.

Virtual Field Trip

Virtual field trips allow students to view and experience places that they would not be able to visit in real-life. In this unit, we will not have the opportunity to engage in a hands-on activity involving radioactive material because it isn’t safe. We live far from the nearest nuclear reactor. A virtual field trip can show the students how a nuclear reactor works to demonstrate the concept. I will pair this experience with a worksheet with guiding questions for the students to fill out. Students may also write in their science journal about this experience in the future.

Rubric Grading

A rubric helps guide students towards a completed project. The rubric will be used to grade the Google-Slides presentation, how well they worked as a group, and their presentation. The rubric will help keep them accountable for their work, keep them on task, and assist them in meeting deadlines. The rubric will clearly describe the type of grade they will receive based on the amount of effort they put into their project. The rubric will also offer a guide for how the students are expected to work in their groups. It will also be a place that the teacher can provide feedback to students about their progress and their presentation.

Classroom Activities

Day One: Begin this unit by informally assessing students' background knowledge about fossil fuels and alternative forms of energy. The teacher will make a list of fossil fuels (coal, oil, and natural gas) and alternative forms of energy (wind, solar, hydroelectric, geothermal, biomass, and nuclear). If the students are unable to come up with a complete list, have them research it or fill in what they missed. Next, discuss why there is a need to change our fossil fuel usage by showing a video about climate change on YouTube. Have the students write a summary about the climate change video in their science journal or on a piece of paper. After that, ask students about their impact on the planet. Have them fill out the Carbon Footprint Worksheet. When they finish, discuss and compare the results. Next, discuss why alternative forms of energy are needed and refer back to the list of alternative forms of energy.

- *Climate Change Video*: https://youtu.be/OqdIbq1Y24g?si=ODb1X2CYk5cYq_SA
- *Carbon Footprint Worksheet*: https://www.ndepscor.ndus.edu/fileadmin/ndus/ndepscor/NATURECamp-TCs/2013TCcampCompostingCarbonFootprint.pdf

Day Two: Introduce the group project by explaining that the class will be put into seven groups. Each group will research one form of energy. Each group will create a PowerPoint or Google-Slides presentation to share with the class. Discuss the graphic organizer to organize the information they need to find and the grading rubric for their presentations. Next, form the groups and assign each group one form of energy. The seven groups are: fossil fuels, wind, solar, hydroelectric, geothermal, biomass, and nuclear. After groups are formed, students can begin their research. A reading worksheet is provided for each group about their energy source. This can be used as a starting point for their research. Students may also use Google to research current usage facts and pictures.

- *Fossil Fuels*: https://www.calacademy.org/sites/default/files/assets/docs/pdf/flipsideenergy_fossilfuels_sciencetextswdiagrams.pdf
- *Wind*: https://www.teachengineering.org/content/cub_/lessons/cub_energy2/cub_energy2_lesson07_reading2.pdf
- *Solar*:
    - https://www.englishworksheetsland.com/topics/3/science/solarenergy/1.pdf
    - https://www.englishworksheetsland.com/topics/3/science/solarenergy/3.pdf
- *Hydroelectric*: https://www.envirothonpa.org/documents/19bHydropowerAdvantagesandDisadvantages.pdf
- *Geothermal*: https://ei.lehigh.edu/learners/energy/readings/geothermal.pdf
- Biomass: https://www.energy.gov/sites/prod/files/2014/04/f14/biopower_factsheet.pdf
- *Nuclear*: https://www.calacademy.org/sites/default/files/assets/docs/pdf/flipsideenergy_nuclearenergy_sciencetextssupp.pdf

Day Three: Students continue research and begin creating presentations. Review the grading rubric to remind students about what to include in their presentations.

Day Four - Eight: Student groups begin presenting. The teacher will decide the order of presentations. Consider completing 2 presentations a day depending on how much time is allotted for the class period. While students are presenting, the audience will record the required information on the graphic organizer used for creating the presentation and turn it in for a grade. The teacher will use the grading rubric to grade each group.

Hands-On Activities

These activities can be paired with the group presentations after each group has presented or can be completed after all groups have presented. Plan for one class period for each activity.

Solar: Build a Pizza Box Solar Oven - https://www.sciencebuddies.org/stem-activities/solar-oven

Wind Energy: MacGyver Activity - https://storage.googleapis.com/kidwind-production/4189f9429f3644149b766bfe6084297f-https_v5.airtableusercontent.com_v3_u_24_24_1705334400000_uGw555rWUArH6hqHlIL2ZQ_pTC76oxniPahqu3Ke-bY7w62CvvqY5G6NIFSlJ3ZxbJ14dgFu7j-6sf8DmsOu1hndLkaX6mV_9_717sGSAEetdr7Mlc5YcY2DvYExHCQbeOJlvh48_SSR3fj52QU2uum_I9aAUVz_QfHQkrIFqlVlQ_egdufC9M3lcE5rqC4nlON1bh67x57FvyV4p0ytiRWGk

Hydropower: Waterwheel Work - https://www.teachengineering.org/activities/view/cub_energy2_lesson08_activity2

Biomass: Biomass Bag - https://blog.constellation.com/wp-content/uploads/2020/07/Biomass-Bag.pdf

Geothermal: This will be a whole class, teacher demonstration – Geothermal Exchange Simulation - https://www.smud.org/-/media/Documents/In-Our-Community/Classes-and-Workshops/Parent-resources/Lesson-6-Geothermal/Geothermal-Exchange-Simulation.ashx

Nuclear: This is a virtual field trip. Have students complete the handout to turn in for a grade. - https://www.teachengineering.org/content/ncs_/lesson/ncs-2026-nuclear-energy-virtual-field-trip/ncs-2026-nuclear-energy-field-trip-handout.pdf

Resources for Teachers

Graphic Organizer - https://docs.google.com/document/d/1UYFDB8I1VSLPJGUn47ss9OM4RuO7z5d9EjY_5D1GoPc/copy?usp=sharing

Grading Rubric - https://docs.google.com/document/d/1iJwItcUhL8Yd__4CESDLkTQK5TAKP0vxQ4PLiZRN0Oo/copy?usp=sharing

Appendix for Implementing District Standards

Environmental Science SOL 7

The student will investigate and understand that Earth's resources are finite. Key content includes: certain resources are nonrenewable because they are replenished at timescales of thousands to millions of years; environmental and commercial benefits and drawbacks of different energy sources to include fossil fuels, biomass, wind, solar, geothermal, hydroelectric, and nuclear power.

The curriculum unit is designed to have the students teach each other about the benefits and drawbacks of fossil fuels, biomass, wind, solar, geothermal, hydroelectric, and nuclear power with their presentations.

Environmental Science SOL 8

The student will investigate and understand that Earth's resources should be conserved. Key content includes: the trend in human consumption of energy will affect future availability of nonrenewable resources; the effects of natural and human-caused activities may either contribute to or challenge an ecologically sustainable environment; individuals can alter their own behavior to reduce their environmental impact; and availability of energy will affect society and human activities, such as transportation, agricultural systems, and manufacturing.

The curriculum unit begins with students assessing their energy consumption. The affects of our current use of fossil fuels is addressed in the YouTube video. These discussions and the carbon footprint worksheet will get students thinking about how to alter their own behavior to reduce their environmental impact.

Annotated Bibliography

Armaroli, Nicola, and Vincenzo Balzani. 2011. "The Legacy of Fossil Fuels." *Chemistry - an Asian Journal* 6 (3): 768–84. https://doi.org/10.1002/asia.201000797. This source has useful information about the history of fossil fuels and some data points. It also includes the pros and cons of fossil fuel usage.

Bagher, Askari Mohammad, Mirzaei Vahid, Mirhabibi Mohsen, and Dehghani Parvin. 2015. "Hydroelectric Energy Advantages and Disadvantages." *Open Science* 2 (2): 17–20. www.openscienceonline.com/journal/energy. This source gives a perspective on the pros and cons of hydroelectric power.

Datta, Arup, Aslam Hossain, and Sanjay Roy. 2019. "An Overview on Biofuels and Their Advantages and Disadvantages." *Asian Journal of Chemistry* 31 (8): 1851–58. https://doi.org/10.14233/ajchem.2019.22098. This source explains the benefits and drawbacks of biofuels. It also gives some background information about biofuels.

Department of Energy. 2024. "Fossil." Energy.gov. 2024. https://www.energy.gov/fossil. Date Accessed: July 13, 2024. This source gives current data for fossil fuel usage.

Fulkerson, William, Roddie R. Judkins, and Manoj K. Sanghvi. “Energy from Fossil Fuels.” *Scientific American* 263, no. 3 (1990): 128–35. http://www.jstor.org/stable/24996937. This source explains how fossil fuels are used for energy and how they are created.

Geothermal Rising. 2022. “How Does Geothermal Energy Work? Easy to Understand Guide from the Experts | Geothermal Rising: Using the Earth to Save the Earth.” July 13, 2024. Www.geothermal.org. April 8, 2022. https://www.geothermal.org/our-impact/blog/how-does-geothermal-energy-work-easy-understand-guide-experts#:~:text=Right%20now%2C%20California%20has%2043. This source has information about how geothermal sources are used and has useful illustrations.

Goldstein-Rose, Solomon, and Violet Kitchen. 2020. *The 100% Solution : A Plan for Solving Climate Change*. Brooklyn, Ny ; London: Melville House. This source gives information about ways to solve our energy crisis. It provides data for our current energy usage and what solutions must happen for a sustainable future.

Jaber, Suaad. 2014. “Environmental Impacts of Wind Energy.” *Journal of Clean Energy Technologies* 1 (3): 251–54. https://doi.org/10.7763/jocet.2013.v1.57. This source provides the pros and cons of wind energy.

Jakhongir Turakul Ugli, Tulakov. 2019. “The Importance of Alternative Solar Energy Sources and the Advantages and Disadvantages of Using Solar Panels in This Process.” *American Journal of Software Engineering and Applications* 8 (1): 32. https://doi.org/10.11648/j.ajsea.20190801.14. This source provides benefits and drawbacks of relining on solar panels as an electricity source.

National Grid. 2023a. “How Does a Wind Turbine Work? | National Grid Group.” Www.nationalgrid.com. July 13, 2024. https://www.nationalgrid.com/stories/energy-explained/how-does-wind-turbine-work. This source explains how a wind turbine works. It includes an illustration on the inner workings of a wind turbine.

National Grid. 2023b. “How Does Solar Power Work? | National Grid Group.” Www.nationalgrid.com. July 13, 2024. https://www.nationalgrid.com/stories/energy-explained/how-does-solar-power-work. This source explains how solar panels work including how it is made.

National Grid. 2024. “The History of Wind Energy | National Grid Group.” Www.nationalgrid.com. Date Accessed: July 13, 2024. https://www.nationalgrid.com/stories/energy-explained/history-wind-energy. This source gives historical context for how wind energy was explored in the past.

Office of Energy Efficiency & Renewable Energy. 2019. “Geothermal Heat Pumps.” Energy.gov. 2019. July 13, 2024. https://www.energy.gov/eere/geothermal/geothermal-heat-pumps. This source explains how geothermal heat pumps work in a home setting.

Orano. 2024. “How a Nuclear Energy Plant Works | Orano.” Orano Group. July 14, 2024. https://www.orano.group/en/unpacking-nuclear/how-a-nuclear-energy-plant-works#:~:text=To%20generate%20electricity%2C%20nuclear%20power. This source explains the parts of a nuclear reactor and how energy is produced at a nuclear power plant.

Reuben A. Holden, Secretary of Yale University, Records (RU 19). Manuscripts and Archives, Yale University Library. This source has background information about how petroleum was first used and led to wide spread fossil fuel usage.

Stefansson, Valgardur. "The renewability of geothermal energy." In *Proceedings of the World Geothermal Congress 2000*, pp. 883-888. 2000. This source discusses how dependable geothermal energy could be as a

main energy source.

U.S. Department of Energy. n.d. “Alternative Fuels Data Center: Biodiesel Production and Distribution.” Afdc.energy.gov. July 13, 2024. https://afdc.energy.gov/fuels/biodiesel-production#:~:text=Biodiesel%20is%20produced%20from%20vegetable. This source explains how biodiesel is made and how it can be used.

U.S. Energy Information Administration. 2023a. “Biomass Explained - U.S. Energy Information Administration (EIA).” Www.eia.gov. July 13, 2024. https://www.eia.gov/energyexplained/biomass/#:~:text=Biomass%20is%20converted%20to%20energy. This source explains how biomass can be used as an energy source.

U.S. Energy Information Administration. 2023b. “Nuclear Power Plants - U.S. Energy Information Administration (EIA).” Www.eia.gov. July 13, 2024.https://www.eia.gov/energyexplained/nuclear/nuclear-power-plants.php#:~:text=Also%20in%20Hydrogen%20explained. This source gives some data points about nuclear power plant usage in the United States.

US Department of Energy. 2014. “Hydropower Basics.” Energy.gov. Office of Energy Efficiency & Renewable Energy. July 13, 2024 https://www.energy.gov/eere/water/hydropower-basics. This source explains how hydropower generates electricity.

Notes

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[1] https://www.nationalgrid.com/stories/energy-explained/history-wind-energy

[2] https://www.nationalgrid.com/stories/energy-explained/how-does-wind-turbine-work

[3] https://www.energy.gov/eere/water/hydropower-basics

[4] https://www.energy.gov/eere/geothermal/geothermal-heat-pumps

[5] https://www.geothermal.org/our-impact/blog/how-does-geothermal-energy-work-easy-understand-guide-experts#:~:text=Right%20now%2C%20California%20has%2043,cityscape%20at%20twilight%20(stock%20photo)

[6] https://www.eia.gov/energyexplained/biomass/#:~:text=Biomass%20is%20converted%20to%20energy,conversion%20to%20produce%20liquid%20fuels

[7] https://afdc.energy.gov/fuels/biodiesel-production#:~:text=Biodiesel%20is%20produced%20from%20vegetable,manufacture%20of%20pharmaceuticals%20and%20cosmetics.

[8] https://www.eia.gov/energyexplained/nuclear/nuclear-power-plants.php#:~:text=Also%20in%20Hydrogen%20

explained,amount%20of%20energy%20is%20released.

9
https://www.orano.group/en/unpacking-nuclear/how-a-nuclear-energy-plant-works#:~:text=To%20generate%20electricity%2C%20nuclear%20power,to%20alternators%20to%20generate%20electricity!

10
https://www.eia.gov/energyexplained/nuclear/nuclear-power-plants.php#:~:text=Also%20in%20Hydrogen%20explained,amount%20of%20energy%20is%20released.

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