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Islands and Their Energy Needs

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Introduction

Today, the world is facing a shift in climate. Humans are seeing an "increase in average temperatures across the contiguous United States with the warmest years occurring since 1998."[1] Heat waves have almost tripled the long-term average with analyses showing that human induced climate change has increased the probability of heat waves. An increase in average temperatures causes increased rates of evaporation which increases the severity of drought in different locations while also contributing to an increase in downpour events in other areas.[2] Data show that the warming trend is caused largely due to anthropogenic effects. These effects will continue if human populations increase as their energy demands will increase. Consequently, society must find a way to combat the CO_2 emissions associated with this increase in energy demand.

In this curriculum unit, I plan to expose high school environmental science students to energy resources available throughout the world, their effect on human-induced climate change, the effect climate change has on islands, and how islands can become self-sustaining. It is important that students develop an understanding of nonrenewable and renewable energy to better understand the implications of the continued usage that fossil fuels have on the world. I will use the course guidelines provided by College Board Advanced Placement for Environmental Science to connect the theme of energy. Students will investigate energy sources available, renewable and nonrenewable, by contributing to a museum exhibit. With this, students will dive deeper into renewable resources by exploring wind, solar, and hydropower to determine which renewable source of energy is best suited for meeting the needs of an island.

It is important to note that the reason many governments still utilize fossil fuels is the fact that they are cheap and widely available. Unfortunately, this is not the case for water locked islands that do not possess oil or coal. Thus, they must pay to ship in oil, coal, natural gas, etc. In an ideal world, utilizing renewable forms of energy that are relatively safe for the environment would be the solution to shipping in coal, oil, and natural gas. However, politics and economics tend to dominate our use of energy. To design, develop, and build the resources necessary for alternative energies the price tag can be hefty. Many of the island governments do not possess the necessary funds to build the infrastructure needed. Consequently, the status quo will then continue with the shipping in of fossil fuels to meet the energy needs of islands until the price tag is mediated, or risks are taken for the greater good.

Content Objectives

Upon the completion of this unit, students will be able to differentiate between nonrenewable and renewable energy sources. The expectation will be that students will be able to describe the positives and negatives that energy has on the environment, living organisms, and on the economics of a nation/country. Likewise, they will need to begin developing an understanding of the distribution of natural energy resources. The advancement of the world has been made possible by societies being able to harness the Earth's natural energy reserves. However, with a change in climate and depletion of Earth features and extinction of organisms, developing and utilizing renewable energy will provide long sustaining sources of energy.

This unit will follow a modified version of the Next Generation Science Standards called the Oklahoma Academic Science Standards. HS-ESS3-2 focuses on the forms of energy production and other resource extraction that have associated economic, and geopolitical costs and risks as well as benefits. Students should be able to evaluate competing design solutions for developing, managing, and utilizing natural resources based on cost-benefit ratios.

Rationale

The audience for this curriculum unit are 10th /11th /12th grade AP Environmental Science students but it can be modified for use with biology students and middle school level students. This unit plan will be taught during my unit on energy resources and consumption. Class scheduling consists of daily meetings of 55 minutes that meet the whole year. The typical class can range from 7 students to 36 students in which I prepare for the latter. I expect the lesson to be completed within a three-week timeframe. Some key concepts associated with this unit are: energy sources are readily available and abundant but they can cause air pollution and release greenhouse gases into the atmosphere, energy sources may be a clean burning fuel, but they can have severe environmental impacts that negate the positives of being clean burning, and there are advantages and disadvantages of using nonrenewable and renewable resources but as a society, we must determine which is the lesser of two evils: cheap energy that is harmful or clean energy that is difficult and expensive to develop and mass produce.

Background

Since the beginning of existence, the need for energy has been prevalent. Without solar radiation, the process of photosynthesis would not have occurred. Through the process of photosynthesis, a new source of energy became available for organisms which allowed the expansion and diversification of living organisms. On this same note, it can be said that "energy systems and social systems are highly interconnected."[3] Over time since the discovery of fossil fuels, there is a direct relationship between the expansion of an area to being developed and its ability to develop large amounts of power. John Urry also stated that the world is only possible through getting fossil fuels out of the ground and then burning them on a gigantic scale. If a nation is to expand and progress, they must possess the ability to create and develop large amounts of power. There are numerous types of energy resources that we use to meet our energy needs in the world, and they can be narrowed into two overarching categories nonrenewable and renewable. Renewable sources of energy are those that could be replenished in a human lifetime. On the opposite side, nonrenewable sources of energy are those that cannot be replenished easily as it takes hundreds of millions of years for the accumulation of them. In a final thought, the world may never run out of fossil fuels. We, as humans, will continue to use the resources we have available and develop new technology to locate and extract these resources. However, as the data show (see Figure 1), continued usage of carbon containing fossil fuels will continue to change our climate as we know it.

How do we know that the increase in carbon dioxide is a result of anthropogenic effects? There are different types of carbon atoms better known as isotopes. Carbon has three isotopes (same atom, different mass due to varied number of neutrons), C^{12} , C^{13} , and C^{14} . $Carbon^{12}$ is the most abundant carbon in the atmosphere and is also the lightest of the three isotopes. Since it is the lighter of the isotopes, plants prefer to take up $Carbon^{12}$ because the atoms move faster and diffuse faster. $Carbon^{13}$ is naturally occurring in the atmosphere and makes up about 1.1% of the carbon in the atmosphere. $Carbon^{14}$ is a radioactive isotope and is produced in the atmosphere from cosmic rays but has a shorter life span than the other isotopes of about 10,000 years; therefore, C^{14} is not found in fossil fuels. This then brings us to the answer to the question: how do we know that the increase in carbon dioxide is a result of anthropogenic effects? When fossil fuels are burned, the emit carbon dioxide. Since the fossil fuels are made from once living organisms that have decomposed, they consist of more ^{12}C relative to ^{13}C; when fossil fuels are burned, the ratio of ^{12}C to ^{13}C in atmospheric carbon dioxide increases providing a snapshot of where the carbon in carbon dioxide is coming from. Additional pieces of evidence from tree rings and ice cores further confirms when there is an increase in burning of fossil fuels, there tends to be an increase in the ratio of ^{12}C to ^{13}C.[4, 5]

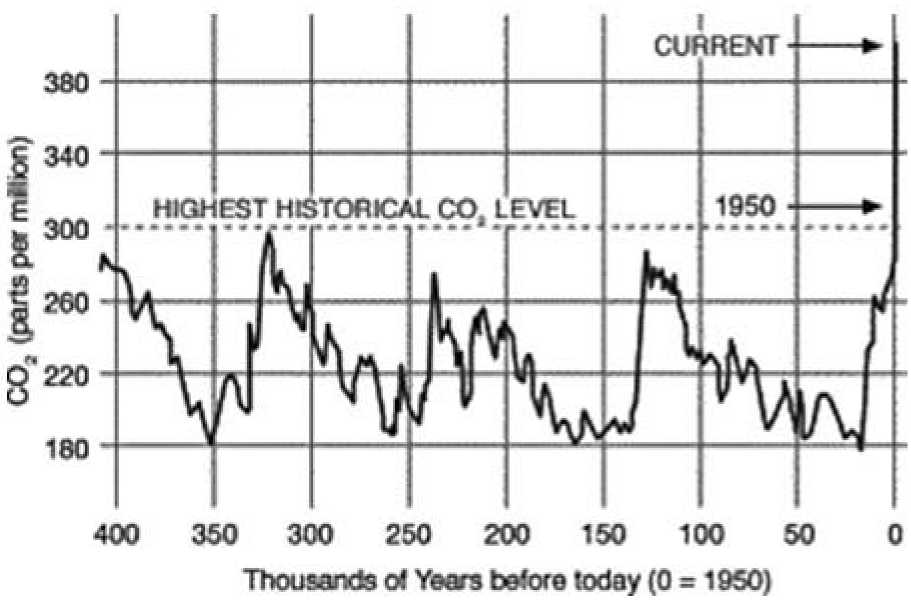

Figure 1: The data show the change in carbon dioxide levels over the past 400,000 years.[6]

At our current rate, there will continue to be an increase in carbon dioxide and, without technology available to trap carbon dioxide gases, the effects of warming will continue to increase. The warming trend will lead to changes in precipitation patterns, increased likelihood of drought and heat waves, frost-free seasons, and an increase in sea levels to name a few.[7] On the same track, the air quality will continue to diminish in different regions of the world. Land degradation will increase extinction rates of plants and animals. We as humans are changing the diversity on Earth which ultimately changes the outlook for the future. For example, "…many species have expanded their ranges poleward in latitude and upward in elevation… changes in composition of ecosystems… montane and endemic species … vulnerable because of narrow geographic and climatic ranges…"[8] The price for fossil fuels may rise significantly in the future due to supply and demand. This will hurt small nations like islands as they must ship in their energy resources. Therefore, it is not only important that islands change how they are meeting their energy needs (see Figure 2), but because islands tend to be the first to experience the effect of rising sea levels due to the increase in average temperatures, it is important that they are leading this shift in meeting energy demands.[9]

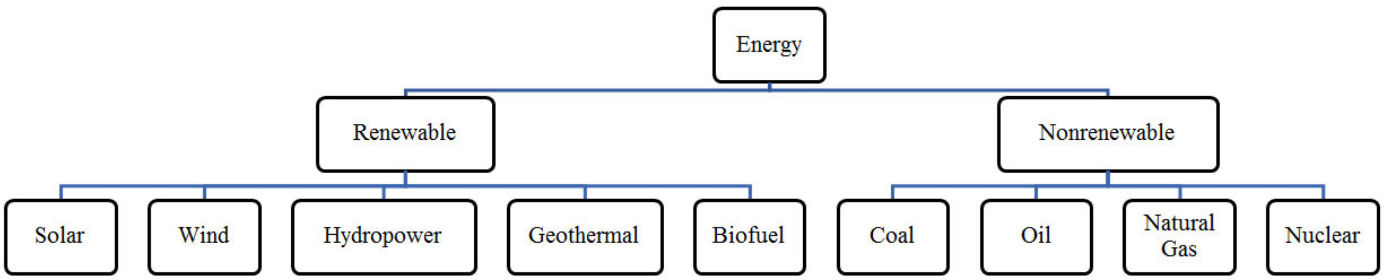

Figure 2: The flowchart shows a general overview of the different energy sources.

Nonrenewable Energy

Oil

The first type of energy source is oil, also known as crude oil. Oil may happen to be one of the most contentious energy sources out there as it has sparked wars, split nations, and has caused the demise of forests, animal habitats, and organisms. Oil is formed from the remains of organisms that lived millions of years ago in marine environments. Once the organisms died, they became buried by sand, silt, mud, etc. and through the impact of heat and pressure over time, deposits of oil developed as portrayed in Figure 3.

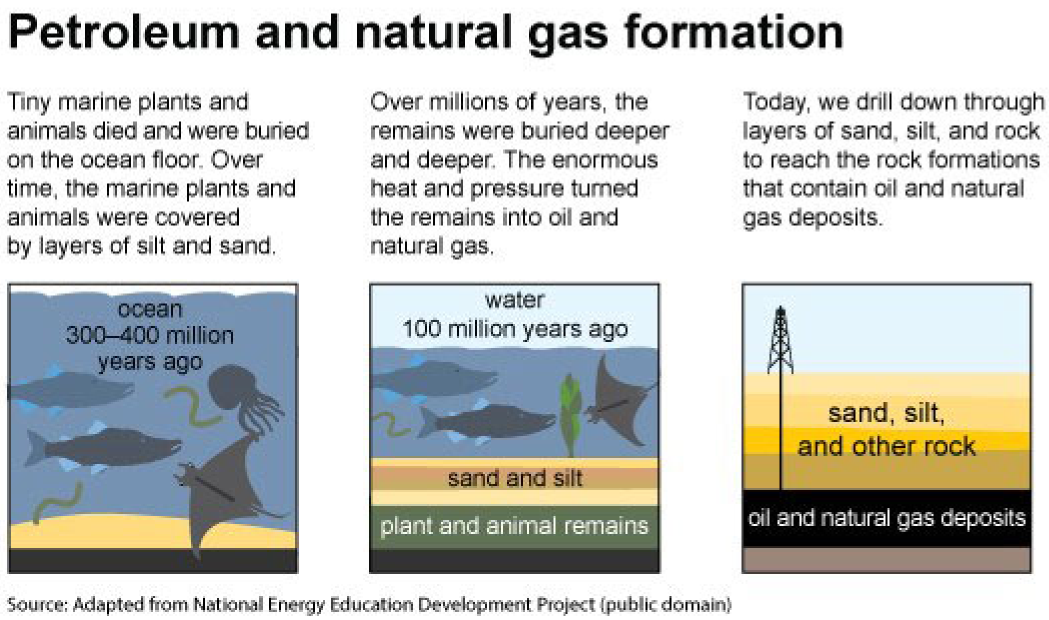

Figure 3: The process of crude oil development.[10]

Globally, oil makes up about 35% of the world's energy consumption.[11] There are many factors that affect the availability of oil which include the demand, technology, rate of removal, cost of production, and market price. We obtain oil from many different places such as shale rock, tar sands, and oil wells. There are several main issues with oil, one being the fact that it contains combustible hydrocarbons, sulfur, oxygen, and nitrogen impurities. Once the oil is extracted, processed, and used, it releases carbon dioxide into the atmosphere. Carbon dioxide is readily available in the atmosphere as it is a natural product of respiration; however, the issue comes from the anthropogenic increases in carbon dioxide levels. "In 2017, CO_2 accounted for about 81.6 percent of all U.S. greenhouse gas emissions from human activities." As mentioned in the background section, there is a correlation between the increase in atmospheric CO_2 and human induced burning of fossil fuels. The percentage of CO_2 has increased with an increase in more modern technology. "Human activities are altering the carbon cycle–both by adding more CO_2 to the atmosphere, by influencing the ability of natural sinks, like forests, to remove CO_2 from the atmosphere, and by influencing the ability of soils to store carbon."[12]

When extracting oil from different locations, there can be an impact on the environment at the surface and at the atmospheric level. One example is the impacts on marine environments when there are marine oil spills. "The toxic effect of oil on marine life depends on the duration of exposure and oil concentration in the environment."[13] Organisms further away from the shore and organisms less likely to be coated with oil are less likely to suffer long term effects from oil spills. There are also human health impacts that can range from direct effects resulting from the presence of carcinogens in crude oil to the indirect effects from air pollution resulting from the presence of oil or the burning of oil. On the same note, different types of oil have their own risks that can vary in their impact on humans and the environment. Conventional oil, which is characteristic of the typical crude oil, has a low-land disruption and a moderate environmental impact compared to unconventional oil. Unconventional oil, characteristic of oils coming from shale rock and tar sands, potentially have a large supply available but to obtain that supply, there is a large environmental impact and severe land disruption.[14]

Natural Gas

Next, there is natural gas which makes up about 23.9% of the world's total energy consumption.[15] Natural gas contains a mixture of different gases such as methane with varying amounts of propane, butane, and hydrogen sulfide. As can be seen in Figure 3 above, natural gas forms in a similar fashion as crude oil. Over time with the assistance of heat and pressure, organic remains become converted into pockets of natural gas deposits. We utilize natural gas in cooking, heating, and as fuel to produce electricity. An upside of using natural gas is that it burns cleaner than oil and coal; however, there is some controversy regarding the extraction of natural gas through the form of hydraulic fracturing. Natural gas is extracted from shale rock which requires drilling of wells into the rock and the use of water, sand, and chemicals to frack the gas. "More than 750 distinct chemicals, ranging from benign to toxic, have been used in hydraulic fracturing solutions."[16] To extract the natural gas from the shale rock, companies inject a mixture of liquid, sand, and chemicals which increases the pressure near the fissures which increases the size of the fissures, releasing the natural gas. Some issues with fracking are water contamination due to leaks in cement barriers, tanker truck spills, migration through fractures, site surface contamination, and disposal of hydraulic fracturing fluids.[17] Consequently, this pollution can seep into natural waterways where communities obtain their source of water for human consumption and irrigation practices. At the same time, another issue arises from aquifers becoming depleted due to the high volume of water needed and the degradation of aquatic habitats near areas of fracking sites. Proponents of fracking claim that there is no actual contamination from the hydraulic fracturing process, but the contamination occurs due to leaks in faulty cement seals and well pipes. This is a result of inadequate inspections and regulation of the natural gas industry and not of the fracking process itself.[18] An additional side effect of using natural gas is the human health impacts from different stages of its usage. The chemicals alone can "… affect the skin, eyes, and other sensory organs, and the respiratory and gastrointestinal systems."[19] When toxic volatile compounds, hydrocarbons, and fugitive gas (emissions of gasses or vapors from pressurized equipment due to leaks) mix with nitrogen oxides in the atmosphere, low-level ozone is formed. As a result, molecules in the low-level ozone can burn the deep alveolar tissue in the lungs causing premature aging which can lead to asthma, chronic obtrusive pulmonary disease (COPD), and are damaging to those that spend time outdoors.[20]

Coal

A third type of nonrenewable energy source is coal. Coal makes up approximately 28.25% of the world's energy consumption.[21] Coal is in solid form which is made up of the remains of plants that were buried about 300 to 400 million years ago as can be seen in Figure 3 above. Over time, pressure and heat convert organic matter to coal that are dependent on time and carbon concentration. Not all coal is the same. Some forms of coal are best used in some industries and not so much in others. There are four different types of coal that vary in their carbon content which makes a difference when burning coal for energy production. The higher the carbon concentration, the higher the heat value is. The first type of coal is anthracite which is the most sought-after coal type for settings that require a high heat value. Generally, anthracite has a concentration of carbon anywhere between 86%-97% which implies that its moisture ratio is low compared to the carbon ratio. The second type of coal is bituminous which is used a great deal in electricity and steel production. Bituminous coal contains about 45%-86% carbon content. The third type of coal is subbituminous which is used in electricity generation and contains a lower carbon content than the previous two at a mere 35%-45%. Lastly, the fourth type of coal is lignite which is used in electricity production as well. Lignite's carbon content varies from 25%-35% carbon and is less durable than the other forms of coal.[22, 23] Coal is burned in power plants to aid in the production of steel, cement, and energy use. There is mostly carbon in coal but there can be trace amounts of sulfur. When coal is burned it produces soot, mercury, carbon dioxide, and radioactive material. The major benefit of coal is the fact that it is very abundant and cheap. Due to this reason, it drives a lot of political decisions made in the United States. There are environmental impacts that affect land, water, and human health. Coal is extracted by mining. As a result, soil and rock become removed, explosives are used to remove mountaintops, and acid mine drainage results from underground mines. U.S. laws dictate how much reclamation must occur with the different types of mining that occur. Another important issue is the emission of carbon dioxide or sulfur dioxide into the atmosphere which contributes to the overall percentage of greenhouse gases which traps heat near the surface of Earth resulting in warming events. This trapped heat helps increase the average temperatures near the surface of Earth. When the temperatures increase, we see an increase in evaporation rates, extreme weather, and extinction events.[24] Emissions from burning coal can cause acid rain, respiratory illnesses, smog, lung disease, neurological and developmental damage in both humans and animals, and pollution that leaches out of ash storage that impacts waterways.[25]

Nuclear

A fourth type of nonrenewable energy is nuclear. Worldwide, there are approximately 450 nuclear power reactors that supply 1.72% of the world's energy consumption.[26] Nuclear energy comes from the process known as nuclear fission where a neutron and a uranium atom collide (Figure 4). When they collide, heat, energy, and neutrons are released. In return, the neutrons continue the chain reaction by colliding with other uranium atoms creating more heat, energy, and neutrons.[27]

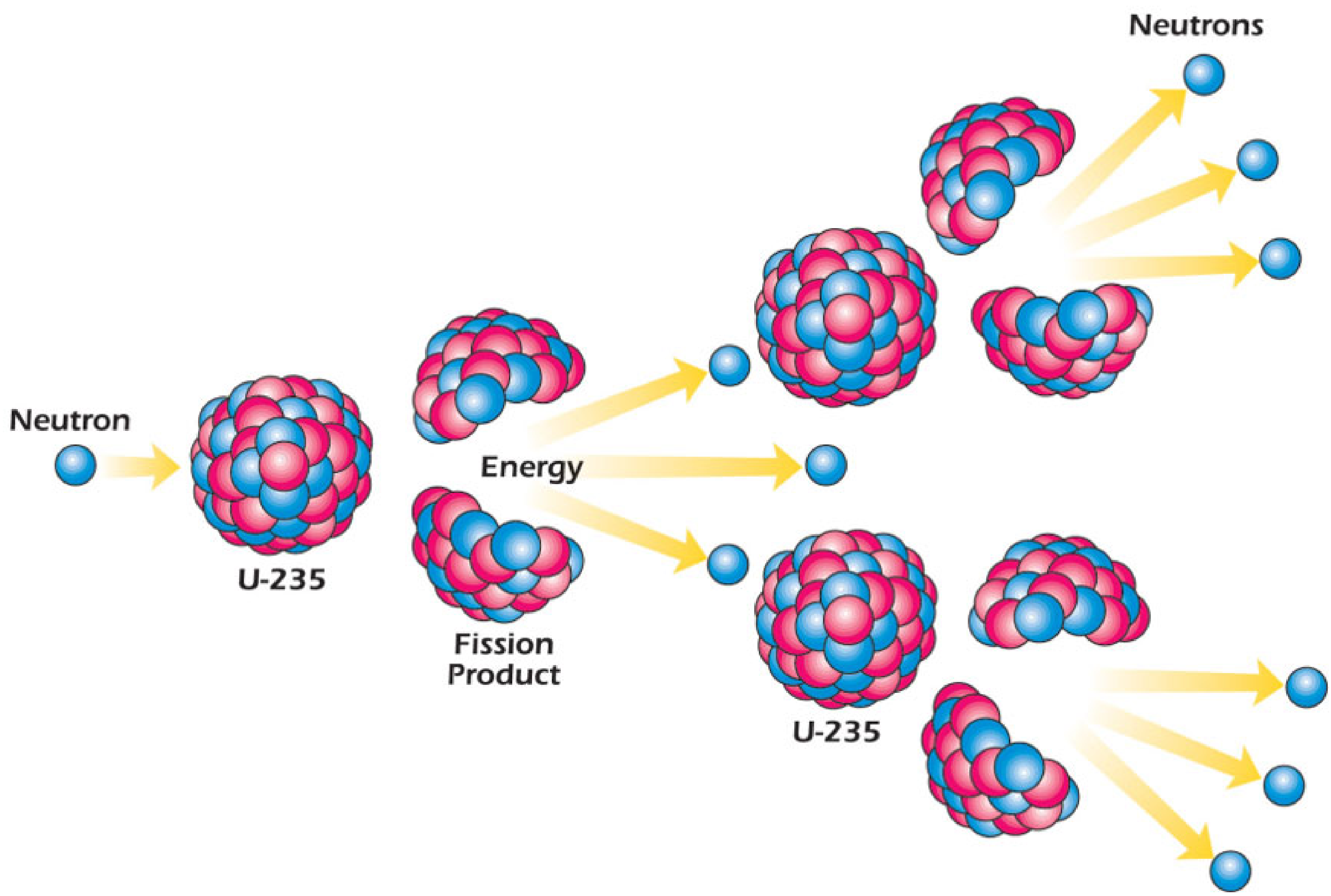

Figure 4: This image depicts the process of an atom of Uranium-235 splitting due to the process of nuclear

fission.[28]

Nuclear energy is created within a vessel in order to contain the reaction and the emission of nuclear radiation as well as the rate at which the reactions occur.[29] The energy created from nuclear fission is used to make steam which powers generators to produce electricity. Some benefits of utilizing nuclear energy are the relatively low cost of production, reliability, and the fact that it can be nonpolluting.[30] At the same time, nuclear energy produces no carbon emissions during its operation. The issue arises in the creation of nuclear power plants. Concrete is a material used in the development of nuclear power plants. The production of concrete utilizes aggregates and rocks as well as limestone. Limestone becomes disassociated by the burning off of carbon dioxide and lime remains, acting as a mortar for the concrete. In this sense, nuclear power plants are not emission free as every step of the production must be considered. One of the other major issues associated with nuclear energy is the environmental risk due to the creation of radioactive wastes. The radioactive wastes produced are easy to transfer to the environment as they can be transferred to the environment by "… workers' shoe covers, clothing, mops, equipment, and reactor water residues."[31] Lastly, just like any man-made energy source, nuclear energy comes with its risks to human health. Some consequences that arise from radiation exposure range from DNA damage, acute radiation sickness, and long-term cancer risks. The associated health risks can be temporary or permanent and can vary based on the type of radiation exposure and the amount of exposure.

Renewable Energy

Solar

One of the major sources of renewable energy comes from the sun. On average, the Earth receives 1.73×10^5 TW of solar energy penetrating the atmosphere.[32] With this amount of energy available, it would make sense as a good source of energy. However, worldwide, solar energy only makes up about 0.29% of the energy consumed.[33] The way in which solar energy is obtained varies and where one can utilize solar energy also affects its use. First, passive solar heating systems absorb the suns heat which is stored in well insulated structures such as concrete, adobe, brick, or stone. The solar heat in passive systems becomes distributed by the natural flow of heat exchange versus a forced system that involves a blower or pump. Second, there are also active solar heating systems in which the heat from the sun is captured by pumping a heat absorbing fluid through special collectors that are mounted to face the sun. The benefit of using an active solar heating system is the energy can be stored and used as needed. Third, another widely used system is photovoltaic systems. These systems convert sunlight energy into electrical energy. "When light shines on a photovoltaic (PV) cell, it may be reflected, absorbed, or pass right through it. The PV cell is composed of semiconductor material, which combines some properties of metals and some properties of insulators. That makes it uniquely capable of converting light into electricity. When light is absorbed by a semiconductor, photons of light can transfer their energy to electrons, allowing the electrons to flow through the material as electrical current. [The] current flows out of the semiconductor to metal contacts and then makes its way out to power your home and the rest of the electric grid."[34] Solar cells can be enticing for large cities due to their ability to be installed in various locations. Many large cities have parking structures with solar panels which contributes to the overall available energy budget. Finally, solar farms can be installed in areas such as deserts where there is a large percentage of solar exposure in any given day which increases the total collection of solar power.[35]

A fourth type of solar collector system is a solar thermal plant. Solar thermal plants concentrate solar energy to “produce the high temperature heat needed to generate electricity… [there are] two main components: reflectors (mirrors) that capture and focus sunlight onto a receiver. In most types of systems, a heat-transfer fluid is heated and circulated in the receiver and used to produce steam. The steam is converted into mechanical energy in a turbine, which powers a generator to produce electricity. Solar thermal power systems have tracking systems that keep sunlight focused onto the receiver throughout the day as the sun changes position in the sky.”[36]

Despite the many positives in solar power, there are negatives from the use thereof. First off, there can be negative impacts on avian species. According to a federal investigation, certain species of birds have been known to fly into the concentrate solar collectors becoming burned when they fly in the line of concentrated light. The panels create a lake effect where some birds view it as a body of water, and they die flying into the panel. Second, there can be health issues that arise for workers building photovoltaic solar farms in southwestern regions of the United States. The California Department of Public Health has received multiple cases of workers contracting Valley Fever. Valley Fever is caused by the inhalation of a soil dwelling fungus called *Coccidioides*. This fungus becomes air-borne when disturbed and can cause influenza-like symptoms and at times pneumonia.[37] Third, there are environmental concerns, but they tend to be site specific. Some examples include visual impacts, routine and accidental release of chemicals, land use, effect on ecosystems and water resources to which all can be minimized with appropriate practices, evaluating appropriate placement, and education.[38] In the end, solar powered sources of energy are sustainably safer and provide fewer negatives to the environment than fossil fuel powered sources of energy.

Hydropower

Next is hydropower which makes up about 2.64% of the world's energy consumption.[39] Hydropower is created by using the energy in water, specifically, using the kinetic energy generated in water to turn a turbine to generate electricity. There are many different designs that convert the flow of water into available energy. Greeks used water to generate power to grind wheat into flour over 2000 years ago. This concept is still used today but on a more modern scale with the use of motors and turbines. The most common type of facility for hydropower is an impoundment. Dams are utilized where water is stored in reservoir and water is released which turns turbines that generates electricity. Next, gravity can also be utilized in mountainous areas where there are sources of water. In this case, water is free flowing from an area of high elevation to an area of lower elevation which can then turn turbines to generate electricity. In other areas, electricity can be generated in open water. Waves generated by wind travel in open water until they encounter an object. If said object has a turbine, the waves spin the turbine generating electricity.[40, 41] Another form of hydropower is brought on by tidal waves. Tidal power is generated from the gravitational imbalances between the Earth, sun, and moon. During the new and full moon, the gravitational pull on the Earth’s surface is greater due to the combined pull of the sun and moon. Larger waves or more prominent tides are a result of this pulling effect. Conversely, during the first and third quarter phases of the moon, the gravitational pull between the sun and moon counteract each other and the effect on the Earth’s surface is less prominent. Tidal energy is not a significant source of energy worldwide as the amount of power needed from tides requires a large change in water level from high to low tide. Likewise, the equipment gets worn out due to the corrosive nature of the water and organisms having to be removed from the equipment. Therefore, there are only so many places in the world that this can be taken advantage of. However, there are benefits such as tidal energy is predictable, energy can be stored and delivered on demand, does not require high cost hardware, etc. A major benefit of utilizing hydropower is the fact that there are low emissions of carbon dioxide and other pollutants. On the other hand, there are disadvantages of using hydropower to meet energy needs. The major disadvantage is the impact on natural processes. For instance, hydroelectric dams can prevent flooding in low lying areas until there is catastrophic flooding. Dams are built to withstand multiple days of flooding and have security measures in place to prevent damage to land, home, and life. However, when catastrophic flooding occurs, towns downstream from dams tend to experience catastrophic flooding and loss of land, property, and life. Likewise, hydroelectric dams can affect the environment and health of organisms. For example, soil degradation can occur due to the accumulation of runoff. A change in hydrologic cycle can bring about a change in the spawning patterns of fish, their fattening, and affect their hibernation cycles. Other influences on water that affects the hydropower system include, but are not limited to, earthquakes, karst, landslides, and river erosion.[42]

Wind

Lastly there is wind power which makes up about 0.73% of the world's energy consumption.[43] Wind energy can be generated by windmills and wind turbines. What is the difference? Windmills generate mechanical energy and are mainly used for more primitive activities such as grinding grain or pumping water. Wind turbines are more advanced and modern in which they are complex pieces of machinery that can be used to harness the wind’s energy to generate electricity. From this point forth ‘wind turbine’ will be denoted as turbine. Wind energy is generated by a turbine turning a shaft that is connected to a generator. As can be seen in Figure 5, a turbine functions by wind turning the blades which turn an internal shaft connected to a gearbox. This initiates a generator to spin converting the mechanical energy into electricity. However, we know that wind can vary by speed and by direction. As a result, wind turbines are designed to rotate to face the strongest winds taking advantage of strong winds throughout a greater portion of the day. At the same time, wind blows stronger with an increase in altitude; therefore, turbines are designed to be atop tall towers to take advantage of the greater wind speeds.[44] Wind turbines are not optimal in all areas as there is a wind speed range. In order to begin generating electricity, the wind speeds need to be in the range of six to nine miles per hour. On the other end, windmills will shut down when the wind speeds begin to top 55 miles per hour.[45]

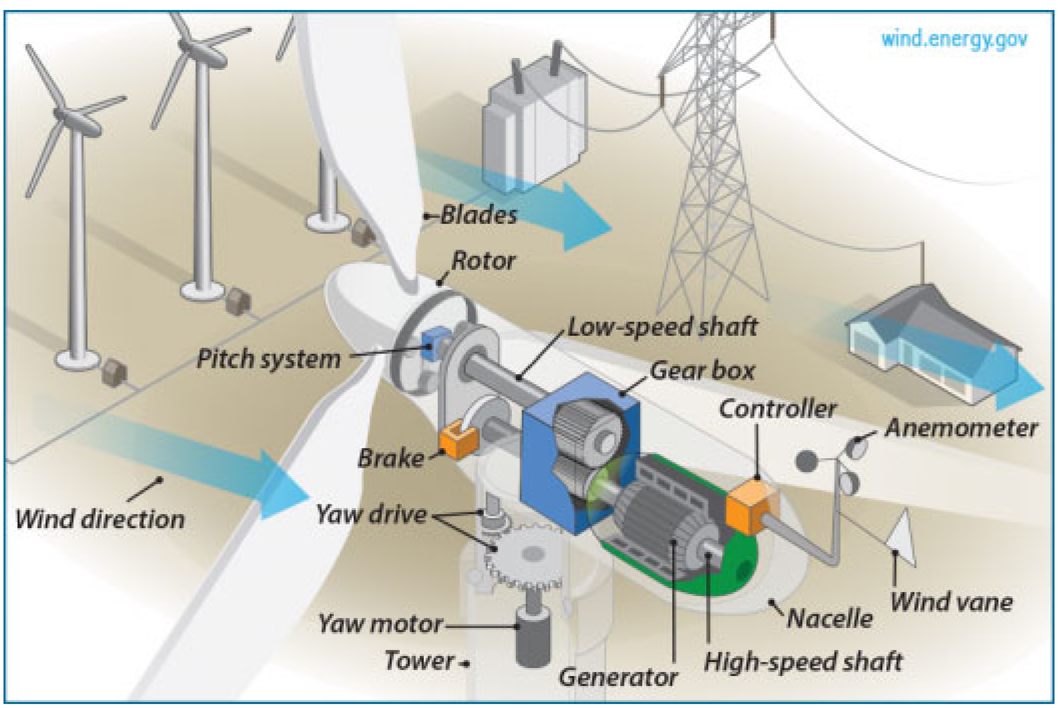

Figure 5: Diagram showing a wind turbine.[46]

There are many benefits of using wind power: it is free, wind is everywhere, requires no fuel, creates jobs, and has a drastically lower impact on the environment compared to fossil fuels. However, there are potential downsides of wind power in the fact that it can be spontaneous due to the intermittency of wind.[47] It can be costly to build and maintain wind farms as there is a huge capital investment to be made. Other concerns are the issues with the impact on nature views, disruption of radar systems for air control due to noise, and the number of birds and bats killed due to collisions with wind turbine blades.[48]

Storing Energy

The leading problem with renewable energy is figuring out how to store large amounts of energy. We can store large amounts of oil, natural gas, and coal. It is easy to extract the resource and store or ship it for later use. However, when it comes to renewables, the ability to store energy is difficult on a large scale. The problem is in developing robust, reliable, and economically competitive means to store energy while matching the most suitable technology to each energy source or location. The intermittency of solar and wind is an issue that surrounds our ability to fully convert infrastructure to renewables as we don't have a way to meet the energy needs during evenings or during periods of no production. There are some potential solutions to the storage issue but to make them viable options on a large scale they need to be modified. One example of storing energy is by pumping water uphill. During the day when there is an excess of electricity production, companies will pump water the water to a reservoir which then can be used in the evening when there is an increase in demand. Another example of storing energy is in a system called *compressed air energy storage*. The process of a CAES system is to compress air and pump it into underground salt caverns. When there is a need for the energy, the air expands which turns turbines at the surface to generate electricity. Some issues arise with the heat being lost to the surroundings which reduces the amount of available energy.[49] A third technology being used to store renewable energy is in the form of chemical bonds. "Thermal energy from the sun can be stored as chemical energy in a process called solar thermochemical energy storage (TCES). The thermal energy is used to drive a reversible endothermic chemical reaction, storing the energy as chemical potential. During periods of high solar insolation, an energy-consuming reaction stores the thermal energy in chemical bonds; when energy is needed, the reverse reaction recombines the chemical reactants and releases energy."[50] A fourth system used to store energy is in batteries. A way in which this application works is to store electricity generated from solar energy. In many regions with solar energy collectors, there can be an access of solar energy in the daytime. For this reason, batteries are used to store electricity from the extra solar energy to be used during the evening or during periods of low production. As is the case with other sources of energy, there is an impact on the environment that include the expensive nature of the project and the degradation of mountain sides due to machinery, equipment, and the need for a reservoir.

Teaching Strategies

To meet the objectives of this unit plan, I will utilize multiple teaching strategies to meet the content objectives. Students will participate in cooperative and active learning settings where they will work together to on a big project to produce a product, in this case a museum exhibit. From here, students will dig deeper into the data behind climate change and how anthropogenic interactions have caused changes in climate. They will then collaborate and prepare a debate to propose solutions to an island's energy needs.

Classroom Activities

Hook/Phenomenon

In order to spark student curiosity, students will participate in an Oil Spill laboratory activity. The reason I am having students conduct this activity at the beginning is I want students' mindsets to begin thinking critically about important issues that could arise from something we depend on in our daily lives. "Oil spills, like most environmental issues, become very political. Many questions are asked, and blame is given."[51] Students will work in groups in an inquiry atmosphere. On the table, students will have access to different tools in which they will be tasked with cleaning up an oil spill. Examples of the tools could include aluminum pie plates, cotton balls, spoons, dispersant, plastic cups, feathers, absorbent pads, and Q-tips. This is in no way an exhaustive list but a good starting point. The objective of the activity will be to simulate a surface oil spill and test different materials for their effectiveness of oil cleanup as well as oil recovery. A variety of both natural and manmade materials will be tested. The goal will be to draw a conclusion as to the impact an oil spill could have on the environment, the economy, and living organisms. An example of a data table students will use to document their activity is below in Figure 6.

Figure 6: Example data table for Oil Spill Lab

With this activity, students will then research two major oil spills the BP Deepwater Horizon spill and the Exxon Valdez spill. They will then complete a Claims, Evidence, and Response (CER) sheet to defend or argue the claim that drilling for oil is harmful to the environment. They will use evidence from the lab activity and the articles on the two different major oil spills. The goal will be for students to start thinking about what consequences, positive and negative, do different sources of energy provide.

Claims, Evidence, Reasoning

Claims, evidence, reasoning strategy is important in the science classroom as it increases the exposure to inquiry students will receive. They are easy to model, easy to assess due to the use of rubrics, and cause students to think about how the evidence supports their claim. At the same time, different subject areas can be tied in such as English where students are focusing on the structure of an essay and appropriate citation of evidence.

Energy Museum Exhibit

Second, after sparking student's curiosity, students will now be tasked with developing a museum exhibit that will start their studies on renewable and nonrenewable energy. The focus for the project is to teach others about the impacts on the environment, economy, and living organisms. The process for this project will consist of research to develop background knowledge, addition of information from current events, production of a product that can range from a poster, website, 3-D model – the possibilities are endless. Some questions/prompts students will be engaging with include: be able to describe the process and pathway in which their energy goes from source to power plant; what are some of the ecological benefits/consequences of their energy source; what are some of the waste products produced, what is done with them, and can they be recycled; expected time frame of energy source in terms of how long it should last until extraction ceases; economic benefits and consequences; and associated laws such as the clean air act, energy policy act, Kyoto policy, pollution prevention act, etc. One of the most important parts of this project is that the product is engaging and interactive. Other students will be learning from the exhibit, and it is vitally important that students are doing something when they visit the exhibit and that the exhibit communicates the key points of their topic in a way that is educational. I like to make this engaging for the students and for others in the school building. Before presentation day (this can take multiple days), I will share the news of a museum exhibit with the administration, self-contained special education classes, and other teachers in the building. This helps in increasing a sense of ownership within the students and helps increase the school wide culture of belonging.

Renewable Energy Stations

After spending time deepening their knowledge of energy, students now will divert their attention towards a world problem. Students will be posed with the issues that surround energy and how those issues might affect secluded islands. As a class, we will spend time at stations building models of a windmill, hydroelectric model, and a solar panel. From here, students will then work in pairs to prepare a debate defending their choice of renewable energy for their choice of an island. Students will be expected to include in their debate the cost of transitioning from nonrenewable energy to majority renewable energy, the infrastructure the island already provides, and potential conflicts of interest this transition may have. At the same time, they will need to include the benefits of switching to their proposed renewable energy source and the positive effects this will have on the island in the short-term and long-term.

Notes

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Appendix on Implementing District Standards

HS-ESS3-2

Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

Disciplinary Core Ideas

Natural Resources:

All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.

Developing Possible Solutions: (secondary to HS-ESS3-2)

When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

HS-ESS3-4

Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*

[Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

Disciplinary Core Ideas

Human Impacts on Earth Systems:

Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

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