Human Energy Choices and Their Impact on the Planet

Kelly Vaughan

Rationale

Our use of nonrenewable energy has increased over time and has changed our reliance on fossil fuels to become the leading energy source. The world is moving at a fast pace and we need energy to support our homes, schools, factories, and transportation services. Our current energy supply is sourced overwhelmingly from coal, oil, and natural gas, which are nonrenewable energy sources. Our reliance on these fossil fuels has caused energy costs to increase and has caused a serious impact on the Earth's ecosystems.

This unit is intended for my eleventh and twelfth grade environmental science students who come from a variety of different cultures and economic backgrounds. These students lack environmental experience even with the changing world around us. Many students are unfamiliar with differences between renewable vs. nonrenewable energy and fail to recognize the environmental sacrifices and the challenges our planet is facing. In the past I have noticed many students struggle with making the connections between how animals and plants interact without human involvement and what negatively can happen after humans are thrown into the mix. I developed a unit where hands-on culminating activities will help students understand what climate change is and how it affects the biodiversity of a specific ecosystem. Students will then have the opportunity to learn how to reverse our carbon footprints and complete research of their own to make our high school and themselves more environmentally friendly.

I think becoming more environmentally friendly, learning how to reduce our carbon footprint, and being knowledgeable about energy resources is an important lesson my students must learn in order for them to take care of our planet for future generations to come. I focused my unit on the basics of climate change, the consequences of climate change for both animal and human ecosystems, and the alternative resources available for our planet. I think my students will be able to walk away with the knowledge of the seriousness of climate change and how to do their part to protect our planet.

Content Objectives

Throughout my Environmental Science semester course, I teach students about basic ecology principles, organism interactions, populations, and environmental interactions. The goals of this final unit are to help students understand the relationships between organism interactions in the wild and how human activity can affect their ecosystems. I intend to teach my students the science behind climate change and provide them with the opportunity to solve an energy problem of their own through capturing tidal energy. Tidal

energy is just one example of a renewable energy source and will serve as an activation activity for students to begin thinking about how we can alleviate our dependency on fossil fuels and demonstrate how to present their given renewable energy source to the class when they complete their research project. Students will then work in small groups to develop a device to harness energy from a wave and present their ideas to the class. This exercise will help kick start our discussion on climate change and move into alternative energy possibilities.

Another goal is to help students dig deeper into understanding the consequences of climate change through a jigsaw investigation of the Adelie and Chinstrap penguin populations. Students will play an individual role in the investigation and graph data to support climate change in Antarctica. Students will then return to their home jigsaw group to report the findings and discuss extended thinking questions on the long term effects of climate change on the Antarctic ecosystem. Many of my students are already familiar with some of the effects of climate change in Antarctica. I chose this particular ecosystem to help students build off of what they already know through prior background knowledge and to help them deepen their understanding of the particular factors that are involved, such as air temperature, melting sea ice, snow patterns, and krill populations, in this ecosystem.

Finally, once students have learned about the importance of climate change, each class will be given a specific renewable energy source to research. Groups will be assigned within the classes to address the pros and cons of each energy source as well as the costs and application process. Students will have to prepare a presentation for the class where each group will teach the class about their findings. Presentations will be recorded and viewable on our online curriculum website for students to use to create their final exam paper on renewable energy. I would like to bring in various administrators and faculty to help support the students in their endeavors to make our high school a more environmentally friendly school and give students the experience of presenting in a public forum to help prepare them for college and career readiness.

Background

In order for students to make the connection between the need and long term effects of energy use, supply, and distribution, I plan to teach my students about the environmental interconnections between biodiversity, human impacts, and climate change. In the previous unit, students will learn about the various carbon, water, and nitrogen cycles and how humans affect these cycles. Basic human impacts such as agriculture, deforestation, combustion, eutrophication, bioaccumulation, and pollution will be taught and explained in depth. These human impacts are drawn on a map and students will learn to identify which cycle each human impact directly affects. We will also go into detail on how fossil fuels are formed, the importance of fossil fuels, and examples of non-renewable energy sources. The differences between the greenhouse effect and global warming will also be

discussed for students to begin thinking about what causes global warming and how excess greenhouse gases can cause our planet to change. This will give the necessary background knowledge needed to explore climate change more in depth in the final unit for my course.

The final unit I will create will help students understand what climate change is, the consequences of climate change, the differences between renewable vs. non-renewable energy, and how renewable energy sources can result in positive environmental impacts. The unit will start off with students exploring the science behind climate change and discussing its causes, including the burning of fossil fuels and livestock's environmental impact on society. Students will learn where coal comes from and the sacrifices that take place when coal is extracted through mountaintop removal. Next, students will discuss general consequences of climate change and investigate, graph and analyze Adelie and Chinstrap penguin population data to determine the long term consequences of climate change in the Antarctica ecosystems. Later in the unit, we will review fossil fuels as a class and begin thinking of how we can move away from non-renewable energy as a society, and use renewable energy as a way to produce electricity. To introduce students to renewable energy, the class will work in small groups to develop a diagram to harness ocean waves. This diagram is intended for students to help solve global energy problems and learn how to properly present a renewable energy source to the class for their final project. Finally, students will collaboratively work in groups to research a specific renewable energy source, while discussing its benefits and cost analysis. Groups will present their renewable energy source to the class and students will take notes to help them develop their end of the semester final paper.

Climate Change

There is now very clear scientific evidence documenting that the earth is warming, and that this warming is due largely to human activity, causing important changes in climate and that rapid and potentially catastrophic changes are very possible in the future.[1] Climate is based on a region's average temperatures and precipitation. When these factors fluctuate it can have an effect on local populations and our planet as a whole. The most noticeable temperature changes are occurring in the Artic and Antarctica Peninsula. Loss of polar ice, rising sea levels, and retreat of mountain glaciers are just a few indications that our planet is in trouble. The loss of ice in the Arctic and Antarctic regions are especially troubling because these are the locations of the largest ice sheets in the world. If this ice melts completely, sea levels are expected to rise over 64 m.[2]

In the past 10,000 years our mild temperatures have been maintained by the greenhouse effect, a natural phenomenon that keeps our planet warm and helps sustain life on Earth. The trapped thermal energy serves as a natural blanket for our planet. A change in our greenhouse gases causes our temperatures to rise or fall and brings unintended consequences to our globe. Although some critics dismiss global warming as

normal, reoccurring events due to natural forces such as changes in the atmosphere and ocean, periodic changes in energy from the sun, and variations in the orbit of the Earth around the Sun, cannot account for the current period of global warming. Natural forces also fail to explain how global temperatures increase more at night than during the day and more in the winter than in the summer, despite the sun serving as a driving force for this "natural" change. [3]

Unfortunately, it is too late to prevent climate change and humans have set these issues into motion. The two predominate causes of climate change are carbon dioxide emissions from fossil fuel combustion and methane emissions driven by human activity. Fossil fuel consumption is currently being used to generate electricity, heat our homes, power transportation, and develop plastics and many specialty chemicals. When fossil fuels are burned the carbon dioxide emissions enter our atmosphere and alter greenhouse gases. Between 1975 and 2005, carbon dioxide emissions increased 70%, and between 1999 and 2005 global emissions increased 3% per year. Methane is also a large contributor to increased temperatures. Two thirds of current methane emissions are by-products of human activity, for example the production of oil and natural gas, deforestation, decomposition for garbage and sewage, and raising farm animals.[4]

Animal Production's Contribution to Climate Change

In traditional times, humans were omnivores to survive throughout the entire year even when crops would not grow during the winter time. Overtime, we have continued to eat both plants and meat even though produce is now available to us year around. Meat, animal fats, fish, eggs, and dairy products provided no more than ten percent of food energy in traditional societies (societies that depended on agriculture, gathering, hunting, fishing, or a combination to survive) but they now account for about thirty percent in affluent countries.[5] Raising and processing of livestock's contribution to climate change has increased over time due to our dependency on animal byproducts and the tremendous amount of energy needed to provide our country with efficient, affordable food. Many Americans now eat meat with almost every meal and some think it is simply unusual to not have some sort of animal by-product on their plates. The United States leads this dilemma by far with over 322 grams of meat per person per day. The livestock sector emerges as a significant contributor to the most serious environmental problems. This includes stresses such as deforestation, desertification, manure excretion, overuse of fresh water, inefficient use of energy, diverting food for use as feed and emission of greenhouses gases. [6]

Our food no longer comes from a farm as many animals come from factories and feedlots where they are forced to eat grain and corn instead of grass like nature intended. This method is becoming more common because animals can be produced at a fast, cheap rate. These "factories" hold hundreds of thousands of animals resulting in huge quantities of manure that contribute to a variety of environmental problems, including greenhouse

gas emissions. Animal's generate about 500 million tons of manure annually and contribute to pollution runoff and leaching waste into surface and groundwater. [7]

Although all animals contribute to environmental change, cattle or beef is by far the least efficient animal by-product. Beef production requires a tremendous amount of space, food and water resources, and factory energy. Globally, agriculture accounted for 12% of human-induced greenhouse gas emissions in 2015. This does not take into account the changes in land use, deforestation, food processing costs, fuel for cultivation and energy, and transport.[8] As a society we must consider alternative food options to meat in order to reverse the environmental impacts of deforestation and excess methane and carbon dioxide.

Consequences of Climate Change on Antarctic Ecosystems

The interaction between ocean conditions and the bedrock beneath a glacier can influence the glacier's evolution, with implications for understanding future ice loss from Antarctica and global sea level rise.[9] Global warming has certainly caused changes for Artic and Antarctica ecosystems. With warming temperatures, melting sea ice, and rising sea levels, artic habitats are bound to be affected. During this unit, students will work in cooperative groups to investigate how sudden changes in temperature, sea ice, and snowfall precipitation can affect the biodiversity of Antarctica. During the activity students will learn how increasing air temperatures affect the Antarctic Peninsula ecosystem starting with analyzing Adelie and Chinstrap penguin population data. Students will also need to study krill densities, sea ice extent, and winter snow to see how each factor impacts the penguin populations as well.

Air temperature data indicated that the western Antarctic Peninsula has warmed by 3 degrees Celsius in the last century. There has been a shift in penguin communities due to warming air temperatures, which is affecting their survival. Adelie penguins are dependent on sea ice for a feeding platform. Warming temperatures are causing sea ice to melt and making it difficult for Adelie penguins to eat Krill, which commonly live on the underside of the ice. Chinstrap penguins on the other hand, thrive in open water and are flourishing due their ability to find food easily. Adelie penguins are slow swimmers and can only find food when there is ice. High demands for Krill increase competition between these two species leading to further population decline. Sea ice also helps control the local climate because it keeps the Peninsula cool by reflecting solar ice back to space. Increasing temperatures cause sea ice to melt and open water to release heat and amplify the local air temperature. Consequently, sea ice acts like a giant cap on the ocean and limits evaporation. Without the ice caps, increased evaporation will lead to more snowfall. The additional snow makes it difficult for Adelie penguins that have already started to nest, and the resulting melted water can kill their eggs.[10]

Students will learn the above information through research and data analysis during the jigsaw activity. At this time students will be required to think back on previous content such as graphing, basic ecology principles, relationships that exist in the wild, and the role of biodiversity in an ecosystem. These topics were taught in my previous units. After the activity the students will need to independently answer critical thinking questions about the connections between climate change and its effects on a specific ecosystem and what the future holds for this particular ecosystem if these changes continue.

Non-renewable vs. Renewable Energy

Non-renewable energy sources are resources that cannot be replaced on the human timescale because they take billions of years to form. Many of these resources were formed before the time of dinosaurs during the Carboniferous period from dead plant and microorganisms that used sunlight through photosynthesis to create energy. Fossil fuels were formed through slow but profound changes of accumulated biomass under pressure and heat. [11] Coal, oil, and natural gas are examples of non-renewable energy sources and are also known as fossil fuels.

There are several advantages and disadvantages of fossil fuels. Although fossil fuels can be easy to extract and are very valuable and versatile sources of energy, they are harmful to the environment because they release carbon dioxide into the atmosphere. Coal is a reliable source of energy but when is burned it releases toxic gases such as carbon dioxide, sulfur dioxide, and nitrogen oxides as pollutants and coal can be very dangerous to extract.[12] Overtime it has become more efficient in many states such as West Virginia and Pennsylvania, to extract the coal directly from the mountains through mountaintop removal. Although this method is safer for the workers and requires less labor, it can be detrimental to the communities and ecosystems. Air pollution, water pollution, and health impacts to the local area are just a few effects of mountaintop removal. At the beginning of the unit, I introduce the current and future impacts of coal production to my class through a documentary entitled “The Last Mountain.” This film explores the effects of coal production first hand and allows the students to see all humans play a role in the impacts of coal.

Oil is inexpensive to extract and can generate a lot of energy and money for the local community however, it releases hazardous gases into the air and oil spills are always a possibility. Natural gas in a cleaner fossil fuel than oil or coal but extracting the gas requires fracturing of rocks and can result in mini-earthquakes.[13] Globally, crude oil production has increased and is now more widespread than coal mining. Almost thirty countries extract oil, but Saudi Arabia, Russia, United States, Iran, and Mexico extract nearly 45% of the global total. Crude oil supplies 40% of commercial energy and fuels more than 90% of the worlds transport.[14]

Our dependency of fossil fuels in the 21st century has caused an increase in atmospheric temperature. The magnitude of this change remains to be seen, but temperatures are likely to increase between 1.4 and 5.8 degrees Celsius by 2100. A change in temperature of 5.8 degrees Celsius is a large concern for our environment and ecosystems. For many reasons, the longevity of a fossil-fueled civilization will come to an end long before we exhaust finite stores of fossil fuels, as their higher extraction costs will lead to new non-fossil sources of energy.[15]

Groups of students within each class will need to investigate and learn about a specific resource. I provide my students with a computer cart during this research period so they can work in groups and get help during class as needed. Students will need to learn about their assigned renewable energy source while learning the uses, the positives and negatives, and the costs over time.

Renewable energy sources naturally replenish themselves over time and can help us become less dependent on fossil fuels in our daily lives. There are many forms of renewable energy such as solar, wind, geothermal, biomass, hydroelectric, and tidal or wave energy. Large-scale use of renewable energy would greatly mitigate a wide range of environmental and human health impacts of energy use. Each renewable energy source has advantages and disadvantages associated with it. It is important to consider which renewable energy sources have zero emissions of greenhouse gases and air pollutants and low impact on wildlife, water, and land resources.[16]

Solar energy can power lights, homes, and heating systems through photovoltaic cells, or PV cells. A PV cell is a device that converts sunlight into electricity. The most common solar cells are made from silicon, a semiconductor, which is the second most abundant element in the earth's crust. Solar energy provides an unlimited supply of clean energy because it does not produce emissions. Unfortunately, the sun is unevenly distributed around the globe and can be inconsistent depending on location. Efficient storage is also be an issue and direct current, DC, must be converted to alternating current, AC, to supply a home with electricity. This causes installation costs to be high, but once paid off it can supply a home with electricity and zero electric bills overtime.

Wind energy is captured through wind turbines to generate electricity. Wind turbines have specialized shaped blades that cause uneven pressure and causes the blades to spin to capture energy. These turbines are tall to access more wind and will allow for more energy to be produced. Although wind energy can be very effective and is a "clean" form of energy, wind is not a steady resource, it can be dangerous to aerial organisms, and cannot be used to provide electricity for all our power needs.[17]

Geothermal energy lies deep in the Earth's core where temperatures can be over 5,000 degrees Celsius. Here geothermal energy can heat underground sources of water to bring warmth above ground to buildings and can be used to heat houses, sidewalks, and parking

lots. In this form geothermal energy primarily serves as a heating resource. Another form of geothermal energy is piping steam to a power plant where steam comes to the surface and is used to turn a generator to create electricity.[18] Geothermal energy is a clean resource but can only be suitable to a particular region usually away from urban areas and has a high installation cost which doesn't pay for itself off until many years down the road. These initial costs often do not make geothermal energy a suitable renewable source due to its 10 percent return.

Biomass energy, a form of solar energy, is made from plants and organisms that were once living. Energy is stored in plants by the process of photosynthesis. Examples of biomass include trees, corn, sugar cane, manure and soy. When burned, these resources generate electricity and can also be converted to biofuel. Biomass is produced from local resources and could also reduce our dependency on foreign imports. Although biomass is easily stored, it requires large amounts of land and pesticide use. Increased use of pesticides can lead to eutrophication, or algae bloom outbreaks, due to increased run off. Land is also a valuable resource and could be used for food production instead of biofuel.[19]

Hydroelectric energy is made from flowing water and is located on large dams to control the flow of a river. A controlled amount of water is allowed to flow through tunnels in the dam to turn huge turbines and generate electricity. Hydroelectric power is fairly cheap to harness and since rivers flow all over the world the energy source would be available to millions of people, however much of the available energy has already been tapped so there is very little availability for the future. Hydroelectric power can also be damaging to the environment because it subsumes existing river habitats, can block migratory fish passages, and can displace communities if a leak occurs.[20]

During this unit, one of the activities used to get the student's to think about renewable energy is a tidal or wave energy project. Although this energy source represents a small amount of energy for our planet, it allows students to begin thinking about possible solutions to the overconsumption of fossil fuels and shows them how to investigate the given renewable energy source to serve as demonstration for their final renewable energy project. Tidal energy captures clean, renewable power but unfortunately is costly and takes a long time to work because of its low power density. During the activity, groups of students will work together to develop an example of how tidal energy can be used to harness the power of ocean tides to generate electricity. This can be done by students by drawing dams, or a device that releases water to turn turbines, or an energy project that floats directly on waves to use the constant movement of water to turn turbines and generate electricity.

Teaching Strategies

KLEW Chart

The KLEW chart is an excellent strategy to use during the beginning, middle, and end of a lesson. I often use this chart to serve as an entry and exit ticket for my students to check for understanding. The chart starts out by asking students "What do we think we know" about a given topic. Here students get the opportunity to use prior knowledge and independent thought to answer what they currently know about climate change in Antarctica. Next students complete the "What are we learning" section after each student has started the jigsaw. Once students return to their home group, they will learn about all of the factors involved in the changing climate of Antarctica. After hearing their group share out they will record what they learned in this section. Once the home group meets, students will work individually to analyze their data and complete critical thinking questions. This will give them a chance to compile their evidence and help them answer the third section of the chart "What is our evidence?" Finally after much thought and investigation, students most likely developed additional unanswered questions along the way and complete the final section of the chart "What are we wondering" and turn it in as their exit ticket. This chart keeps students on task, encourages independent thought, and requires students to support their answers with evidence from investigation.

Jigsaw

This strategy requires student participation because each member of the group will be accomplishing a different task. During the Antarctica case study, students begin at their home group where they choose a specific role in the penguin population activity then break into working groups where they are responsible for becoming experts in their role. Students have to graph and analyze data and return to their home group with evidence to support the consequences of climate change. This strategy helps students take ownership in their work because when they return to their home group they will be the only expert in their role. In the home groups, students teach the other students about their individual data analysis. This strategy will also be used during the renewable energy project, where each group of students will serve as an expert for one of the five assigned renewable energy sources. Students will have to learn how their energy source works, its pros and cons, and whether their energy source can truly support the world's energy needs in the future. Each group will teach the class about their assigned source and all students will piece the jigsaw together in order to gain knowledge about all five renewable energy sources.

Group Research and Analysis

When students work in groups they learn to experience how to work as a team and the challenges that can exist in the workforce when working towards a common goal. This

strategy has students research particular concepts and create a presentation to teach other students in the class about their findings. Students will work together to learn about a component of their class assigned renewable energy source and create a visual aid to help keep the audience engaged. Each group will have to serve as an expert on their assigned topic while the audience takes notes, ask questions, and answers the handout the presenting group assigns. This strategy will be very important to each student because the information they obtain in each presentation will help them develop their position on energy to finish the course. Student creativity, professionalism, and delivery will also be considered when assigning grades.

Activities

Climate Change and Its Consequences

LEQ: What is mountaintop removal and its impacts? What is the difference between climate, climate change, and global warming? What are the consequences of climate change?

This lesson is intended to teach students about the consequences of climate change and the sacrifices that are being made for us to have efficient, cheap energy. The lesson will start by introducing students to coal production then students will learn the five major consequences of climate change through a group jigsaw poster project.

Activation

Students will begin thinking about how coal is produced, the environmental impacts that occur from coal extraction, and the sacrifices people make for us to have electricity through a documentary called “The Last Mountain.” This film is to serve as activation for the unit as a whole because it reviews one of the major fossil fuels that we use and students can see first-hand where coal comes from. Most students understand that coal is a fossil fuel and that we use it for industrial production and electricity, but what they fail to see is where it comes from and what impacts it has along the way for communities and the environment. The documentary takes place in the Appalachian Mountains in West Virginia where students will take a close look at the impacts of mountaintop removal for a community at a loss for words due to the environmental and health impacts they face. Water pollution, air pollution, black lung, and brain tumors are just a few things the communities in West Virginia are currently facing at an expense for electricity. At the conclusion of the film, students will see that this is an important issue that involves everyone because we all use electricity and we all contribute to the problem. Students will complete an exit movie reflection found in Appendix 2, where they must identify and explain how everyone is connected to coal, the environmental impacts that exist, and what future solutions are available for Coal River Mountain in West Virginia.

Instruction

After the documentary, I will teach students the process of mountaintop removal step by step and explain how it became the common method of coal extraction from underground mining. The mountaintop removal process begins with deforestation of the landscape and the blasting of the mountains to remove the overburden. Overburden is the area that lies above the coal including the plants, soil, and rock. This overburden is then dumped over the valleys into the hollows so the coal can be extracted. Workers will extract coal using machines and dig through the left over debris. The coal then becomes processed and chemically treated. The left over "slurry" or toxic sludge is placed in impoundments within the community that have the liability of leaking or breaking over time. Finally, the coal companies must treat the site through reclamation. Here they will simply place rock and grass seed overt the extracted area and move on to their next site. This method has become a more efficient way of extracting coal because it is safer for the workers, requires less labor, and is physically easier and more efficient to get to the coal. Before mountaintop removal, coal was extracted underground by workers. This was a dangerous act for the workers because methane explosions were common and many times there was only one way out of the mine for the men. This method was more environmentally friendly however, it took longer to extract the coal and in smaller quantities.

Next, we will move into the differences between climate, climate change, and global warming since these terms are related but also have very different meanings. Climate refers to the average weather conditions for an area over a long period of time. Global warming is the gradual increase of temperature due to the excess greenhouse gases emissions produced from burning of fossil fuels for electricity. Climate change includes a change in temperature including the consequences of climate change. Currently, temperatures are on the rise due to fossil fuel combustion and the consequences are caused by human impacts. I will introduce the five major consequences of climate change, such as the disruption of the water cycle, rising sea levels, health effects, changes to ecosystems, and challenges to agriculture and the food supply. I will assign students to jigsaw groups where they will work together to learn about a one of the five given consequences and develop a poster presentation to teach the class about their topic.

Activity

Students will be assigned a jigsaw group with a particular consequence. In their groups, students will work cooperatively to research their consequence and identify the causes, effects, interesting facts that exist, and provide a graphic image for the poster. All groups will be given a graphic organizer where each of the five consequences is listed. Each student must fill out their individual consequence notes, and be prepared to teach the audience about the remaining four consequences of climate change. This lesson will take approximately two class periods because the first day will introduce the consequences and allow students to create posters. The second class will allow students to finalize

theirs notes and presentation methods, and allot time for all groups to present their consequence. While each group presents, the students will complete a graphic organizer identifying the causes, effects, and facts. As a class, we will check for understanding by discussing the main points of each consequence and why climate change is ultimately affecting humans and the environment globally. Posters will be collected and students will be graded based on the quality of their posters and their professionalism during their presentations.

Climate Change in Antarctica

LEQ: What evidence exists to explain the inter-ecosystem effects of climate change on the Antarctica Peninsula?

This lesson is intended to teach students the effects of climate change for a specific ecosystem. Students understand that climate change is harmful, but in this lesson they get to see first-hand how biotic and abiotic factors affect each other and what negative impacts it can have along the way for the organisms that live there. Students will work collaboratively to conduct a scientific investigation of the Antarctica Peninsula and use evidence to explain the interconnected ecosystem effects of climate change between 1975 and 2003.

Activation

In order to activate student's brains on the case study, I will have students complete a KLEW entry ticket found in Appendix 3 that will also turn into their exit ticket at the end of class on day one of the lesson. This lesson requires at least two full 90 minute class periods depending on your students abilities. The KLEW chart allows me to check for understanding during part one of the case study. Students will the first section of the chart by answering what they already "know" about climate change in Antarctica. At this point, most students have prior knowledge of the melting ice sheets and warming temperatures. Next, students will conduct a climate change investigation in their jigsaw groups and record population and climate data. Once students have discussed their data in their home groups, students will answer the second and third sections of the chart "what are you learning" and "what is your evidence." Here, they will have to put their knowledge and data on paper, which allows me to do a quick check for understanding at the end of class. Finally, after students have completed their initial data, group discussion, and class discussion, they will answer "what are you wondering" before they leave class and turn in the entire chart as an exit ticket.

Instruction

Although this activity allows for much student engagement and independent work without the teacher, students will need to have a basic understanding of graphing

principles. At the beginning of the year, my class learns about graphic basics, dependent and independent variables, how to set up a graph, and how to use a graph to answer questions. Prior to the case study lesson, I will review these principles with the class in lecture format. Next I will give each student a data table and have them set up a line graph from start to finish on graph paper and use their graph to answer analysis questions. As they work, I will walk around to answer any questions they may have and check their graphs off along the way to see if any student needs additional assistance setting up their line graph. In order to complete the case study, each student will need to know how to set up a line graph from given data, define increments, and use their graph to determine what happened to their data and why. This is very important for the case study because each student will be graphing a different data set within the case study. Students cannot simply copy their neighbor because everyone in the group will have a different set of data and everyone will be relying on each student's data to complete the case study. This is challenging for the student and has them take responsibility for their own data to share with the group.

Activity

In order to teach students how climate change affects a specific ecosystem, students will work together in a jigsaw case study, found in Appendix 4, to learn the interconnections between air temperature, snow precipitation, sea ice, Adelie penguins, Chinstrap penguins, and krill. Students will begin the activity by reading the background case study information and identifying the six factors involved in the case study. I will provide the graph for the changing air temperature and use this factor as a demonstration for how to complete the case study. Students will look at the graph in pairs to determine what happened to the air temperature and why, while using data to support their reasoning. We will record the first analysis question as a class then students will be assigned a home group to determine their individual role within the case study. In the home groups, each student will be given one of the remaining five roles in the form of a reading. Each reading will have basic information about the factor and a data table they will use to set up their line graph.

Once students have read their assigned role, they will find other students within the class with the same role. For example, if they were assigned krill, they will find the other students who also have krill and sit together as a "working group." There will be a total of five working groups, one for each factor. These groups will work collaboratively to determine how they will set up their graph. Each student will use the data table to create an identical line graph as their neighbor. After all graphs have been completed, the students will draw in a line of best fit and determine whether their data increased or decreased overtime and why using their graph and reading. Students will complete the analysis section of the case study for their particular factor and be ready to share out their findings when they return to their home group.

Back in their home groups, students will go around the table to report out their individual findings and record information under the analysis sections. Students will need to record whether the factor increased or decreased and why and use specific data to support their reasoning's. I will check in with each group to make sure all data is accurate and complete. Once students have completed the analysis section, they are ready to independently answer the critical thinking case study questions and write a summary of their overall findings. The case study worksheets will be turned as their assessment at the conclusion of the case study. I will be grading each student's work based on their understanding of the interconnected ecosystem effects of climate change and how this particular ecosystem will respond to these effects in the future.

Non-renewable vs. Renewable Energy

LEQ: What is difference between non-renewable and renewable energy? What renewable energy sources are available to support the world's future energy needs?

This lesson is intended for students to see the differences between non-renewable and renewable energy and gain an understanding of the pros and cons associated with each. Students will learn what the future of the world's energy holds and research a particular energy source to share with the class. Each group project will give students the knowledge they need to walk away with a solid understanding of the examples of renewable energy, and which energy source is more likely to supplement non-renewable energy in the future.

Activation

To get students to begin thinking about the types of renewable energy that exist and what requirements are expected for their renewable energy project, I will use tidal energy as a demonstration for the class. Even though tidal energy represents a small amount of energy for our planet, it will allow students to begin thinking about the other types of energy that exist and how the globe can move towards a cleaner resource. The activity begins by asking students what a tide is and why we have tides. This allows students to use background knowledge to help understand the material. Next, students will pair up and use the computers to research tidal energy in order to identify how it works, the pros and cons that exist, and what percentage of energy it currently provides for our planet. During this research period, students will actually be mimicking the tasks that will be required during their group project. After students have investigated tidal energy, we will discuss the energy source as a class and check for understanding. Finally, students will be given an energy problem, found in Appendix 5, to design an energy device that will harness the power of ocean tides to generate electricity. Student devices will vary from drawing dams, devices that release water to turn turbines, or a device that floats on waves and use the movement of water to turn turbines. After students have completed their design, they will have the opportunity to share their drawings with the class and explain

their idea. At the end of the activity I will play a video that explains the full concept of tidal energy in action and introduce the renewable energy project.

Instruction

Students will need to understand the differences between non-renewable and renewable, examples, and the pros and cons of each in order to complete the renewable energy project. At the beginning of this activity I will review non-renewable energy and introduce renewable energy in the form of a graphic organizer, found in Appendix 6. In a previous unit, students learned about fossil fuel creation during a carbon cycle lesson. We discussed how and when fossil fuels were formed and what they are used for. Since students will have some prior knowledge of non-renewable energy this will help them move toward renewable energy. I will provide students with two frayer models found in Appendix # to teach the students about the differences that exist and give them just enough understanding to set up our discussions and prepare for the renewable energy project.

Activity

Once students have learned about the differences between non-renewable and renewable energy and researched tidal energy, I will begin talking about their final project for the class. I will start by discussing the project objectives, what will be required for the project, and what group and renewable energy source they are assigned to. Students will walk away with a basic understanding of the examples of renewable energy that exist, the pros and cons associated with each, and likelihood of renewable energy serving our planet for the future. This activity will requiring one to two weeks depending on how much in class time you give the students to conduct their research and how many groups you have to present.

During the first week students will work in groups to research one of the five assigned renewable energy sources. Topics will include solar, wind, hydroelectric, geothermal, and biomass energies. Students will have access to computers and develop a presentation in the form of a PowerPoint or infographic to present to the class. Each presentation must include their energy source, how it works, the costs associated with installation, the pros and cons of each source, and the current level of energy it provides for the planet. Each group will also have to develop a graphic organizer for the audience to fill out during their presentations. This will allow all groups to learn about the other examples of renewable energy and have notes to support their learning. Students will be required to upload their presentations and graphic organizers on our schools supported class website. All presentations and documents will be accessible for students even after the presentations are over.

During the second week of the activity students will present their renewable energy source to the class and have the audience complete the graphic organizer for their reference. During this time, I will grade each group on their presentations, graphic organizers, and professionalism during the entire project. Students will also be given a chance to review their group members and their efforts. This project will serve as a large assessment grade for the class and help students walk away with a solid understanding of the renewable energies that exist and where our world energy source could move towards in the future.

Appendix 1: NGSS Standards

HS-ESS2-2: Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems

HS-ESS3-2: Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios

HS-ESS3-3: Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity

HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems

HS-ESS3-5: Analyze geoscience data and the results from global climate change models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts on Earth systems

HS-ESS3-6: Use a computational representation to illustrate the relationship among Earth systems and how those relationships are being modified due to human activity (acid rain, ocean acidification, and climate change)

Appendix 2

Exit Ticket Reflection: The Last Mountain

1. Maria Gunnoe says, "*You're connected to coal, whether you realize it or not. Everybody's connected to this*" What are the ways identified in the film that <u>everyone is connected to coal</u>?

2. Identify <u>and</u> explain at least 2 environmental impacts of mountaintop removal:

3. Bill Raney, president of the WV Coal Association, says "*I don't think people understand where electricity comes from. I think most people feel like it is an entitlement…and we don't need to worry about where it comes from because every time we flip a switch it comes on*." Do you agree that we are entitled or have a right to electricity? Why or why not? Whether or not we are entitled to it, what responsibilities do you think should come along with using electricity?

4. What future energy source is available for Coal River Valley <u>and</u> how does mountaintop removal limit this possible solution?

Appendix 3

K•L•E•W Chart

What Do We Think We KNOW?	What Are We LEARNING?	What is Our EVIDENCE?	What Are We WONDERING?

Appendix 4

Case Study: Climate Change in Antarctica

Name: _____ Date: _____ Period: _____

Introduction – Background Reading

Air temperature data indicate that the western Antarctic Peninsula (Figure 5 .4) has warmed by about 3°C in the last century (Clarke et al. 2007). Although this relatively short-term record is only from a few research stations, other indirect lines of evidence confirm the trend. The most striking of these proxies is a shift in penguin communities. Two species of penguins, in particular, have been influenced by climate change: Adélie penguins and chinstrap penguins (Figure 5.1).

Figure 5.1

(Left) Adélie penguins *(Pygoscelis adeliae)* are a breed on the coast of Antarctica and surrounding islands. They are named after the wife of French explorer Jules Sébastien Dumont d'Urville. Adult Adélies stand 70–75 cm tall and weigh up to 5 kg.

(Right) Chinstrap penguins *(Pygoscelis antarctica)* are primarily found on the Antarctic Peninsula and in the Scotia Arc, a chain of islands between the tip of South America and the Peninsula. Their name comes from the black band running across their chins. Adult chinstraps stand 71–76 cm tall and weigh up to 5 kg. *Photographs courtesy of Michael Elnitsky.*

Why is sea ice so important to Adélie penguins? First, sea ice is a feeding platform for Adélies. Krill, the primary prey of Adélies on the Peninsula, feed on microorganisms growing on the underside of the ice (Atkinson et al. 2004). For Adélie penguins, which are relatively slow swimmers, it is easier to find food under the ice than in large stretches of open water (Ainley 2002). Second, sea ice helps control the local climate. Ice keeps the Peninsula cool by reflecting solar radiation back to space. As air temperatures increase and sea ice melts, open water releases heat and amplifies the upward trend in local air temperature (Figure 5.2 and 5.3). Finally, ice acts as a giant cap on the ocean, limiting evaporation.

Figure 5.2: **Melting sea ice amplifies the effects of climate change.**

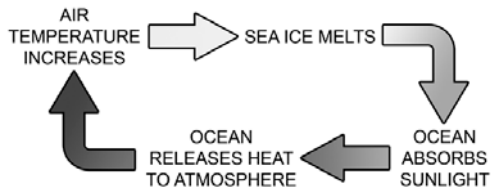
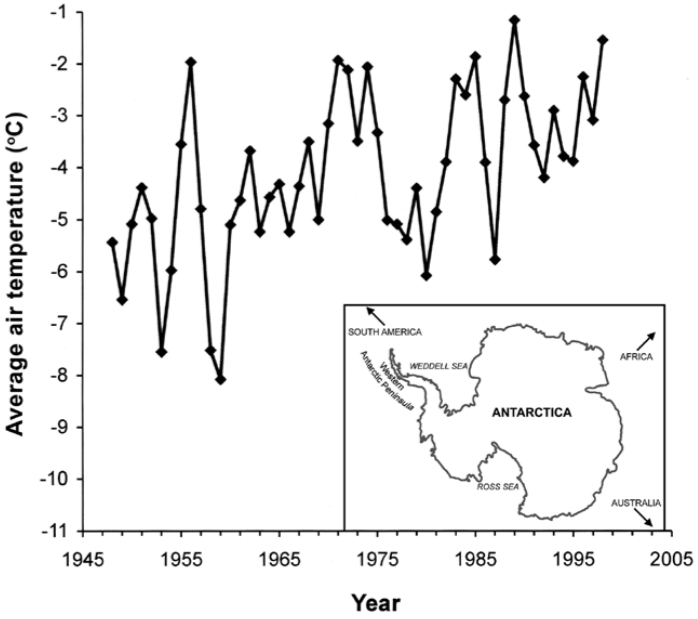


***Figure 5.3*: Climatologists: Air temperature data set**

Source: Data compiled from the Palmer station, Antarctica Long-Term ecological Research (LTeR) data archive.



<u>Home Group Analysis Questions:</u>

1. **How has the ecosystem of the Antarctic Peninsula changed in the last 50 years? Explain by citing data from each group member's represented data:**

Air temperature –

Adélie penguin populations –

Chinstrap penguin populations –

Krill densities –

Sea ice extent –

Winter snow –

Appendix 5

Tidal Energy Design

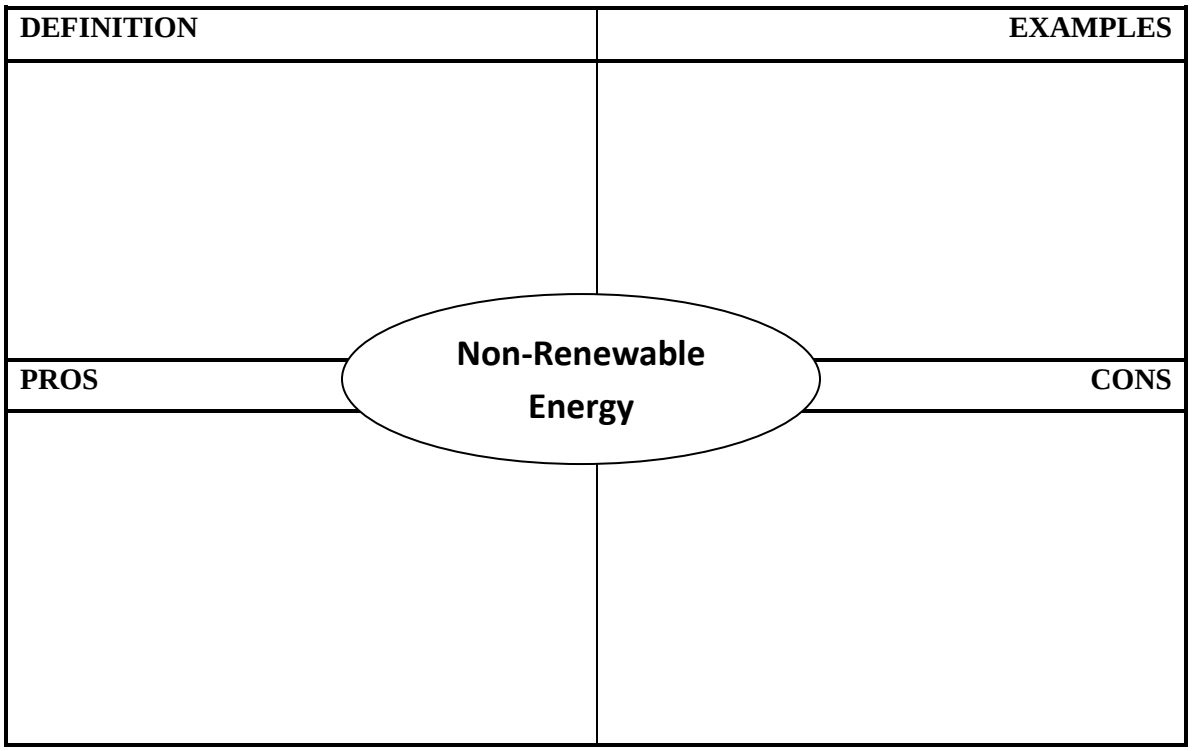
Our country has an energy problem….can you help solve it?
Suppose you could design a device to 'collect' energy from ocean waves? Perhaps your device could help alleviate our dependence on fossil fuels?

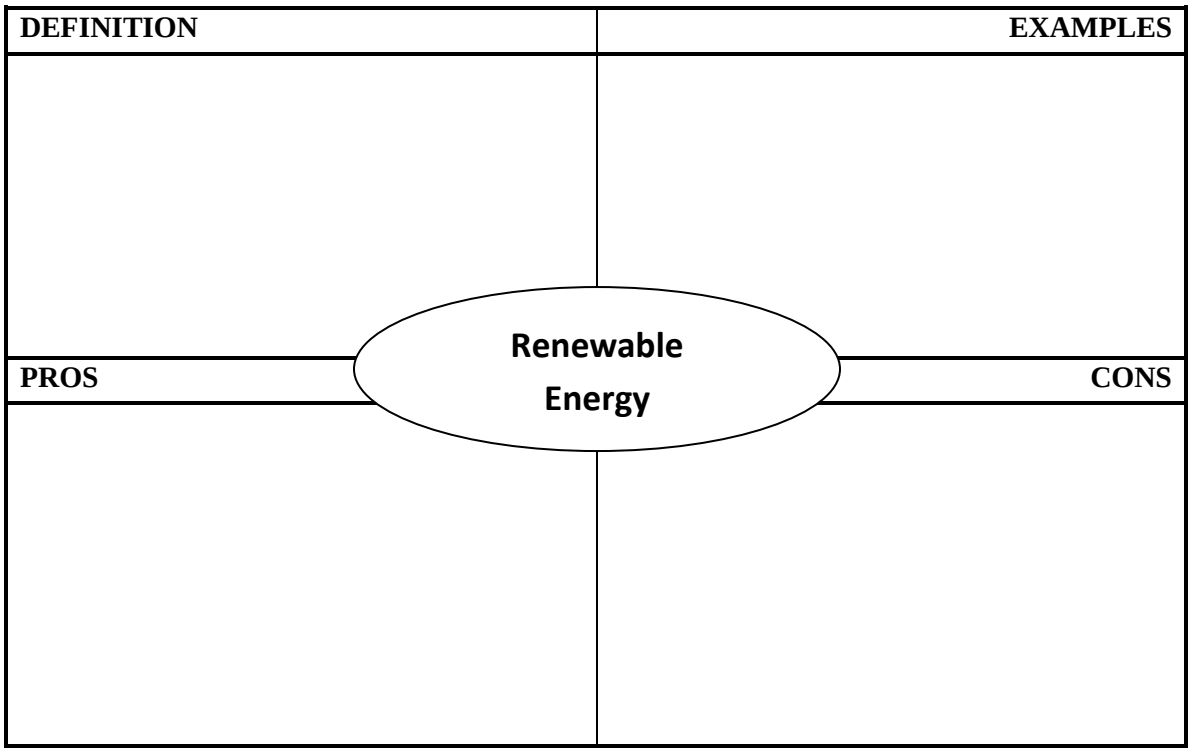
Here is your problem…

You are given the task of harnessing some of the energy of the ocean's waves. You are the chief design engineer of an energy company. The company builds a platform that is anchored to the floor of the ocean. The platform sits above the water's surface within sight of the shoreline, and is large enough to support the equipment you will need. Your company has also provided you with all of the necessary materials. The "wave energy capturing device" you create must turn the shaft on a motor. By turning the shaft on the motor, the kinetic energy of the spinning shaft can be transformed into electrical energy.

Work with your partner to use the space below: Create/draw a device that will harness energy from ocean waves and generate electricity:

Appendix 6


DEFINITION
EXAMPLES
Non-Renewable Energy
PROS
CONS


DEFINITION
EXAMPLES
Renewable Energy
PROS
CONS

Bibliography

Lonnie G. Thompson, "Climate Change: The Evidence and Our Options," Association for Behavior Analysis International (2010) 153-170, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2995507/

This source provided me with some basic information regarding climate change, evidence of climate change, the causes and effects, and possible solutions. It also discussed loss of polar ice as evidence of climate change, which was helpful knowledge during my Antarctica case study.

Vaclav Smil, *Energy: a Beginners Guide* (London: Oneworld Publications, 2006), 101-185.

This book provided much insight into the basics of energy. We used this book in our DTI seminar frequently, and I used chapters 4 and 5 for several of my citations within my paper.

Center for Ecoliteracy. "The Last Mountain Discussion Guide," 2011. https://www.ecoliteracy.org/sites/default/files/uploads/shared_files/TLM_Guide.pdf

This is an excellent teacher's guide to learn about the importance of mountaintop removal for coal production. In this guide you will learn about the documentary, how to use the guide to meet your classroom needs, discussion questions by theme, and basic vocabulary used in the film.

YouTube. "The Last Mountain Documentary." Last modified September 21, 2012. https://www.youtube.com/watch?v=6neSdVOh_BM

This link gives you a free full version of the documentary "The Last Mountain." This is the film I used as a student activation for coal production at the beginning of my unit.

Constible, Juanita, Luke Sandro and Richard E. Lee, Jr, *Now You Sea Ice, Now You Don't.* National Science Teachers Association, 2008 Part II Climate Change Case Studies, 77-97, http://static.nsta.org/files/PB225Xweb.pdf

This case study will provide a collaborative scientific investigation for students on the effects of climate change on the Antarctica ecosystem. This link will give the teacher the necessary background information on Antarctica climate change, how to perform the case study, detailed student data pages for working group analysis, and critical thinking questions for the students at the conclusion of the case study. This source along with Appendix 4 will allow you to complete the case study in full.

Notes

[1] Lonnie G. Thompson, "Climate Change: The Evidence and Our Options," Association for Behavior Analysis International (2010) 153-170, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2995507/
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[10] Juanita Constible, Luke Sandro, and Richard E. Lee, Jr, *Now You Sea Ice, Now You Don't* (National Science Teachers Association, 2008) Part II Climate Change Case Studies, 78-80, http://static.nsta.org/files/PB225Xweb.pdf
[11] Smil, *Energy: A Beginners Guide*, 101.
[12] "Non-renewable Energy" *National Geographic Education*, http://nationalgeographic.org/encyclopedia/non-renewable-energy/
[13] "Non-renewable Energy"
[14] Smil, *Energy: A Beginners Guide*, 128
[15] Smil, *Energy: A Beginners Guide*, 105
[16] Mark Z. Zacobson and Mark A. Delucchi, "Providing All Global Energy with Wind, Water, and Solar Power, Part I: Technologies, Energy Resources, Quantities, and Areas of Infrastructure, and Materials," Energy Policy 39 (2011): 1155, http://web.stanford.edu/group/efmh/jacobson/Articles/I/JDEnPolicyPt1.pdf
[17] "Renewable Energy" *National Geographic Education*, http://nationalgeographic.org/encyclopedia/renewable-energy/
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[20] "Renewable Energy"