A good planet is hard to find: climate change, energy, and global sustainability

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This curriculum unit is recommended for:
Earth and Environmental Science 9-12 grades

Keywords: Energy Resources, Climate Change, Sustainability, Coal, Oil, Natural Gas, Nuclear, Biomass, Solar

Teaching Standards: See Appendix 1 for teaching standards addressed in this unit.

Synopsis: Sustainability, global climate change, and energy consumption are increasingly in the forefront of the news. This curriculum unit introduces high school students to the challenges we face as a global society in trying to provide enough energy resources for our growing population while leaving the Earth in a condition where future generations can thrive. Energy is a concept that spans the sciences and applies to almost everything we do as a human race. Clarifying this concept is one goal of the curriculum unit. A second goal is to provide the students with the basic necessary information to begin to understand the immense challenges we face in making choices about energy resources. Providing enough energy for our projected population of 9 billion will require innovative ideas and international cooperation if we are to leave planet Earth in a condition that allows future life. Students are introduced to these challenges and invited to provide their own solutions. The exercises in this unit can be accomplished using the internet sources cited as well as common inexpensive materials. The unit has been designed to allow flexibility in modifying activities to meet the needs of Earth and Environmental Science courses at all high school levels.

I plan to teach this unit during the coming year to 135 students in **Honors Earth and Environmental Science grades 9-12**.

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Introduction

Teenagers typically see things in black and white simplistic terms. There is either a right or a wrong answer and everything can be interpreted literally. The goal of this unit is to help 10th-12th grade students in my Honors Earth and Environmental Science and AP Environmental Science classes discover that environmental issues are seldom black and white. They will accomplish this by learning about climate change and the energy resources available which could lessen the impact of the human contribution to greenhouse gas emissions. A second goal is to define the concept of sustainability and encourage discussion of solutions to climate change and energy resource needs that allow humans to continue to live sustainably on planet Earth. The teenagers of today will be responsible for finding the correct mix of energy technologies that meet our growing demand in the future as well as tackling the complex economic, sociologic, political, and scientific concerns that accompany this global challenge. It is important that they begin to understand the issues as well as the impact any solution(s) may have on our ability to survive and thrive on Earth.

Mallard Creek High School is home to over 2400 students and is located in a part urban-part suburban setting in the University City area of Charlotte, North Carolina. Mallard Creek High School is one of over 30 high schools in the Charlotte-Mecklenburg School District and was recently recognized with the Silver Award for National Excellence in Urban Education. The student body is diverse and is comprised of 63% African American, 21% White, 6% Multi-Racial, 5% Asian, and 5% American Indians. Mallard Creek High School is incredibly fortunate to have a dedicated staff of teachers; over 50% have obtained a Masters or Doctoral degree and 15% have obtained National Board Certification. The school has consistently maintained a graduation rate of around 95% since its opening in 2007.

I currently teach Honors Earth and Environmental Science (HEES) as well as AP Environmental Science (APES) to students from diverse academic and socio economic backgrounds. Most of my students are in the 10th, 11th, or 12th grades. MCHS operates on a 4 x 4 - 90 minute block schedule for all classes except AP level courses. This means that I teach a HEES class every day for a full semester and then teach it again to a new class of students for the second semester. AP courses meet every other day for the entire year. This school year I teach two sections of HEES and two sections of APES.

The curriculum for Honors Earth and Environmental Science is mandated by the North Carolina Department of Public Instruction (NCDPI). I follow the pacing guide provided by NCDPI as well as their general outline of units and standards to be addressed in each unit. The Honors Earth and Environmental Science course is a laboratory-based science class emphasizing the function of the earth's systems. Emphasis is placed on the human interactions with the earth's geologic and environmental systems, predictability of a dynamic earth, origin and evolution of the earth system and universe, geochemical cycles and energy in the earth system. The AP Environmental Science curriculum is provided by The College Board and is an interdisciplinary course that incorporates earth science, biology, and chemistry into understanding the interactions that occur in our environment. It is useful if the student has had two laboratory sciences (biology and chemistry are recommended) as well as at least Algebra 1 prior to entering APES. However, CMS only requires that students pass Algebra I prior to taking an AP science course. This results in an academically diverse student population in APES. The most important criteria for an APES student is to possess a strong work ethic and the ability to be a self-motivated learner.

Background

Time is the only difference between climate and weather (1). Weather is the local variations on a day to day basis in temperature, precipitation, wind, and cloud cover. Climate is the variation of these parameters over decades or longer. The world was classified into different climate zones by Russian climatologist Vladimir Koppen and his work is widely used today to facilitate comparison of different regions of the world over long time periods. His classification scheme is based on temperature and precipitation. Climographs are typically constructed to facilitate these comparisons. A climograph displays temperature and precipitation for a year in a given location. Different climates show different patterns on climographs and can easily be compared as well as correlated to biomes.

In recent years, few topics have seen the media attention that climate change has received. Students are often confused by the myriad reports either supporting or refuting climate change. In addition, they have heard the term “global warming” interchanged with “climate change” for most of their cognizant lives. Defining climate change as the preferred term and understanding what this means is the first step in a student’s understanding of the effects that burning fossil fuels is having and will have on our ability to survive on planet Earth.

Numerous lines of evidence now point to the fact that humans are very likely changing the climate through increased output of carbon dioxide gas into the atmosphere. The line of reason follows: 1. The normal and natural greenhouse effect is critical and without this subtle effect we would not have life on Earth; 2. There is factual and historical evidence that strengthens the link between climate and increased temperatures

with carbon dioxide; 3. Historical data indicates that the amount of carbon dioxide has been rapidly increasing since the industrial revolution; 4. New technologies have allowed more precise measurements and confirmation of rising global temperatures and sea levels that accompany these rapid rises in carbon dioxide levels. (2)

Energy is involved in everything that happens on planet Earth. Simply put, energy is the ability to do work. There are two main types of energy: kinetic and potential. Kinetic energy is the energy of motion. Potential energy is energy that is being stored for future use. Energy can take many forms including electrical, mechanical, gravitational, and chemical to name a few. When we eat breakfast, some of the chemical energy that is provided by the food is stored in the cells of our bodies for future use and some is used immediately to power our bodies. The Law of Conservation of Energy states that energy is never lost or gained in any system. It always remains constant. This means that energy can change from one type to another such as from kinetic to potential but the amount of energy always remains the same. (4)

In the context of this curriculum unit, energy is defined as the resources or fuels we have available to supply our daily needs in our homes, schools, businesses, and industries. When you turn the lights on in the morning, the electricity does not magically appear. The light is the end result of a long process that begins with a particular fuel or energy resource. There are two main types of energy resources currently used across the world: renewable and non-renewable. Renewable resources are those that can be replaced during a normal human life time. Non-renewable resources are those that cannot be replaced during normal human life times. Recently, new terms have been proposed to categorize energy resources. The terms "income" and "inherited" energy resources will be used in this curriculum unit because they encompass not only the finite or non-finite nature of the resource, but the historical or future aspect of our large selection of energy resources (5). Income resources are those that show promise for sustaining our future and include hydropower, biomass, photovoltaics, wind, solar thermal, tidal, and wave power. Inherited resources are the energy fuels that we have used historically and that we rely on presently to provide the energy for our daily lives. These include oil, coal, natural gas, and uranium.

One challenge to comparing different energy resources is the fact that each type of energy is typically defined with a different set of units. For example, coal is expressed in tons, oil in barrels or gallons, and natural gas in cubic feet. In other parts of the world, the units are reported as their metric equivalents such as cubic meters instead of cubic feet. This makes it particularly difficult to compare the consumption and production of different types of energy across the globe, especially considering that energy production has many different variables that need to be considered already when determining the efficiency of that particular resource. Recently, a new unit called a cubic mile of oil (CMO) has been used to eliminate some of the confusion. This unit was originally defined in the 1970s during the energy crisis (5). A cubic mile of oil (CMO), is

equivalent to 724 billion gallons of oil. If you poured oil into a swimming pool that was a mile wide, a mile deep, and a mile long, it would fill the pool to three quarters full. In the year 1965, the world used 1 CMO and by 2000 the number was 2.7 CMO. By the year 2006, we had increased that number to 3.1 CMO. In 2013, the amount of oil the world used was 3.6 CMO (6). If we continue at this rate, the amount of oil the world will need by 2050 is 9 CMO (5). A great deal of this increase is due to the emerging economies in East Asia.

The following summarizes the income and inherited energy resources that we currently have at our disposal for use in supplying the world's needs (5):

Inherited

Coal

This resource is widely available throughout the world except in the Middle East region. Currently, there are approximately 120 CMO available which should last about 80 years given the current and projected rates of consumption. To supply the world with 1 CMO, 2 coal plants would need to be built each week for the next 50 years. China and India are currently building coal plants at this rate.

Oil

Current reserves of oil are estimated at approximately 46 CMO although this is somewhat dependent on the prevailing price. In addition, between 35 and 94 CMO of oil resources may be available given new technologies for extraction. At our current rate of consumption, this supply should last 50 years.

Natural Gas

Current supplies could last as long as 100 years. The world currently has 42 CMO of assured reserves and between 34 and 66 CMO of likely or possible reserves available. Since the largest natural gas reserves are located in Russia and the Middle East, this may become a political problem for nations that rely on that supply.

Nuclear

Nuclear power is the only inherited resource that does not emit greenhouse gases and it has the best chance of realistically expanding to reduce our dependence on coal and oil. The main problem with nuclear power is its public acceptability and the lack of a permanent solution for disposal of the waste. Uranium supplies are currently 28 CMO but could be extended with slightly higher prices for uranium. Thus, if we increased nuclear power to 1 CMO per year, we would have a number of decades of supply left.

However, in order to supply this 1 CMO by 2060, we would need to build 2283 additional plants or 1 per week for the next 50 years.

Solar

We receive 23000 CMO of energy from the sun each year. However, there are a limited number of locations that can provide sufficient solar intensity to make the use of this technology economical. The largest solar plant (100 MW) is located in Spain. We would need to construct 27 such plants per week for the next 50 years in order to supply 1 CMO of energy from solar power. An additional challenge is that these plants would cover 27000 square miles and cost $14 trillion. Storage of solar energy is also a challenge that needs to be overcome.

Geothermal

The current use of geothermal energy amounts to only 0.05 CMO but could be increased to as large as 4 CMO per year. Approximately, 0.8 CMO per year would be useful for electricity production. In order to expand the use of geothermal energy beyond 0.1 or 0.2 CMO, we will need to develop new technologies.

Wind

The potential for wind to contribute to the mix of energies available to the world is greater than 40 CMO per year. In order to accomplish this, we would need to build 1200 wind turbines per week for the next 50 years. The main challenge to utilizing wind energy is the development of a large scale storage system. In addition, public acceptance must be won and the impact on migratory birds and farm animals must be taken into consideration.

Hydroelectric

Approximately, 0.2 CMO per year of global energy is produced by hydroelectric power. Most of the large rivers in the world have been dammed and thus the potential for increasing this supply is limited. River flow is not uniform and the availability factor for hydro power is also a challenge and is currently assumed to be about 50%. If we were to somehow discover locations and technologies to increase hydropower to 1 CMO per year, we would need to build 153 Three Gorges Dams over the next 50 years. This would require 1 such dam every 4 months.

Biomass

The potential for biomass to supply energy is 20 CMO per year. At an average of 5 tons per acre, it would require 5 million square miles of land to produce 1 CMO per year of

energy. In addition, the social equity of using food for fuel needs to be considered. Thus, most current research into biomass uses switch grass instead of corn or soy.

Rationale

The common core standards for earth and environmental science have changed the focus of this course from basic earth science concepts (such as rock and mineral identification) to larger questions of water resources, climate change, and sustainability (including energy resources). EEn 2.6.2 and 2.6.3 state that students will be able to "explain changes in global climate due to natural processes" and "analyze the impacts that human activities have on global climate change (such as burning hydrocarbons, greenhouse effect, and deforestation)". Therefore, the first part of this unit will define climate change and global warming. These are terms most high school students have heard in the news, but their actual understanding of the concepts is typically limited.

Common Core standard EEn 2.8.2 requires that students "evaluate alternative energy technologies for use in North Carolina". When high school students think of alternative energy technologies, their knowledge is typically limited to solar energy and electric cars. In addition, students often believe that we can meet our energy needs by just installing more solar panels and reducing the number of coal plants. This part of the unit will explore all current energy technologies and their pros and cons.

Throughout the lessons on climate change and energy resources, the concept of sustainability will be defined and discussed. EEn 2.6.4 requires analysis of changes to Earth's systems and their effect species diversity and the health of ecosystems. Sustainability is typically defined as meeting our current needs as a global society without hampering the ability of future generations to meet their needs. Students need to understand that potential solutions to climate change and energy resource challenges will not be of value unless these solutions allow us to leave planet Earth habitable for future generations (3).

Part 1 – Climate Change

Although global warming and greenhouse effect were buzz words a few years ago, the excess emissions of greenhouse gases into the atmosphere by human activities is better described with the term climate change (2). Students who are home for several snow days in North Carolina rightfully question whether the globe is really warming excessively. When Cleveland, Ohio receives 26 inches of snow on an April Easter Sunday and the Indians have their first 4 home games snowed out, people are skeptical that the globe is warming. Climate Change is a better term because it does not limit the changes we are currently seeing to warmer weather. Some of these changes include more intense hurricanes and tornados as well as non-typical weather patterns (such as 6 inches

of snow in Charlotte). In addition, the greenhouse effect is a natural process on planet Earth and one without which we would not have life (3).

In order to accomplish these goals, the students will first learn how climate zones are defined and characterized and why climate is different from weather. They will analyze data showing that the planet has been warming rapidly over the past 100 years and they will correlate this rise in temperatures to the start of the industrial revolution (2). The concept of sustainability will be defined and students will calculate their ecological footprint. To experiment with lowering the ecological footprint, the students will play an online energy challenge game produced by Duke Energy Corporation.

Part 2 – Energy Resources

There are currently numerous energy resources to choose from including the traditional forms of energy such as coal, petroleum, natural gas and nuclear (7). Relatively new technologies such as solar, wind, biofuels, photovoltaics, geothermal, and hydro hold promise for the future and their use is on the rise today. In order to meet the needs of our growing global population, a mix of energy resources will be needed. Not one energy source will be the savior that eliminates climate change or reduces the amount of greenhouse gases already in our atmosphere.

In order to evaluate the efficiency and future usefulness of various energy resources, students should have a basic understanding of how electricity is produced. The three steps to electricity production, generation, transmission, production, will be described and the most compelling pros and cons of each resource outlined. The goal is to get spur student's thinking and encourage them to begin forming questions that will be answered later in the unit.

Students need to understand that many factors go into decisions about which energy resources to use (7). These factors include not only scientific capabilities, but also the sociologic, political, ethical, and economic factors for each country or political entity that the energy is needed to serve. In order to explore these factors, the students will learn about the cap-and-trade policy including why the United States does not participate in this policy (7). Students will view clips from the video SWITCH and participate in discussion about the pros and cons of various resources (8). The SWITCH Energy Project is a non-partisan effort to educate people with a basic understanding of energy resources and encourage practical instead of polarized conversation. In addition, SWITCH promotes conservation and efficiency as partial solutions to our looming energy crisis. SWITCH provides free copies of their documentary as well as other educator resources.

Finally as a culminating activity to this unit, the students will participate in two group activities. In the first activity, a utopian village will be designed and sketched on a

large piece of paper by each group. The village will be the group's concept of the perfect place to live as an adult and will include their thinking on how they will survive and still sustain the Earth for future generations. The second activity requires the groups to analyze and determine the correct mix of energy resources for a specific country that they have been assigned. Each group will be given data on the resources available as well as the amount of energy that must be produced. They will determine the resource mix that they feel will meet their needs and will be allowed to provide some of their needs by trading or buying from other locations. After they have determined their best mix of energy resources, they will be given a crisis event such as an earthquake or a political change and they will need to reevaluate their mix of resources given the new conditions.

Activities

The activities we will accomplish have been set up around the questions and topics that need to be covered during this unit. I have purposely left some activities in a general state so that they can be used in either my HEES or APES classes. For the APES classes, they will be able to delve deeper into some topics and spend more time on certain activities than my HEES classes.

What is Climate? How is it different from weather?

Before we can understand why climate change is a concern for our world, we need to define climate and distinguish it from weather. In order to accomplish this, the students will take a few notes from power point slides. They will also read a description in their textbooks of the Koppen climate classification system. Finally, they will plot data on climographs and compare different climate zones.

What is Climate Change/Global Warming and are humans really causing the problem?

The students will come to class having already read a selection of articles that they find on scoop.it. They will be assigned these readings at the end of the previous unit in order to allow enough time. Three or four students will be assigned the same articles so that when they arrive in class they will group with the students who read the same articles. Discussion questions and probes will be provided to guide their understanding and help them pick out the important aspects of the climate change information. By the end of class, each group will have constructed a simple poster and presented their information to the class.

Define the potential effects of climate change

Students will take notes from a power point or other presentation that defines and gives examples of the different effects of climate change. An important point to emphasize is that we are already seeing the effects of climate change across the globe. In addition,

further changes are projected to occur. As an example of these changes, the students will look at maps and data of sea level rise that has already been recorded and analyze this information.

What is sustainability and why do we care about our carbon footprint?

Sustainability is a far reaching concept in both the Earth & Environmental Science and AP Environmental Science curriculum. In this unit, we learn about sustainability from the standpoint of being able to provide enough electricity and transportation fuel to our growing population without damaging planet Earth beyond repair. The students will explore these concepts by traveling to one of the computer labs and using an online tool to calculate their ecological footprint (9, 10). They will then continue using the computers to play the Duke Energy Game (11). Duke Energy Corporation offers a free online game where players attempt to provide enough energy for the global population in 2050 while reducing Duke Energy's carbon footprint. Prior to leaving class, the students will turn in a write up of their ecological footprint as well as a definition of sustainability in their own words.

Distinguish inherited from income energy resources and understand electricity generation

For this portion of the unit, I plan to bring in a guest speaker from either Duke Energy or the Electric Power Research Institute to describe the general process of generating electricity. If I can't line up a guest speaker, I will describe the process myself. The students will then view clips from the video SWITCH and discuss in small groups the various forms of inherited and income energy resources. We will focus on a few from each category.

Define the global energy challenge

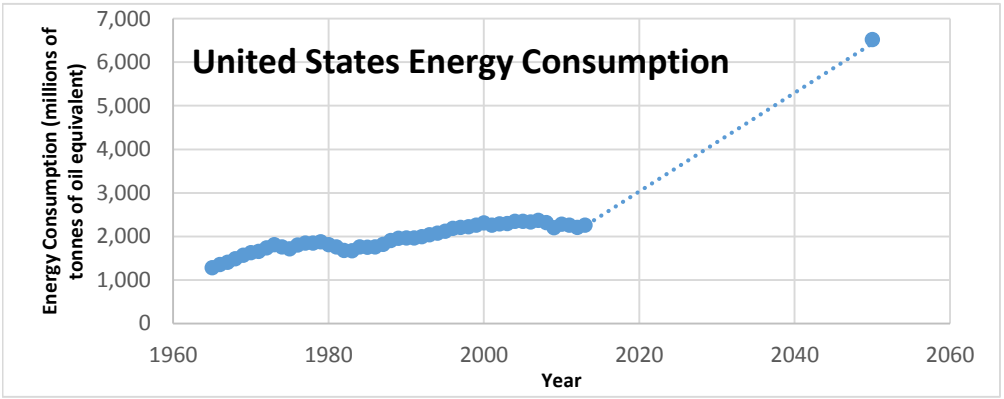
Day 1

The first culminating activity for this unit is a look at how countries decide which energy resources to use and how they make decisions that govern the use of energy. In order to make this activity more real for the students, they will engage in a village creating scenario. The students will be in small groups and will be charged with creating their vision of a utopian village. Each group will have a large piece of paper and drawing tools to make a sketch of their ideal village. Few constraints will be placed on this portion of the exercise so that the students will be free to design whatever type of village or city they would like to live in as adults. The main point of this exercise is to stimulate discussion about what is feasible and what is not feasible as well as what energy resources they will use and how these will be provided.

Day 2

The students will be in small groups of three or four and each group will be given a card with information about their country (Figure 1). The information they will receive includes population, current and projected energy resources, current production, projected need, and social or cultural considerations. Their task will be to provide the energy needed for their country by choosing a mix of energy resources. They will be told what amount of production they need to achieve. The students will be able to trade with other countries if their country allows this and if there is opportunity to trade. After the students have worked for a given amount of time and come up with their proposals, an event will happen to their country such as an earthquake or a war. This event will necessitate that they reevaluate their mix of energy resources. To summarize, each group will present and defend their decisions and a matrix will be constructed on the white board that includes each country and their initial and final energy resource mixes.

United States of America **Country Card**



Current population: 319 million (July 2013)
Projected population in 2050: 438 million

Current energy resources: Coal, oil, and natural gas primarily. Smaller contributions from nuclear and renewables

Projected energy resources: Natural gas availability and price will increase and decrease respectively making it a popular resource.

Cultural considerations: There are few cultural considerations concerning energy resources in the United States. Nuclear power has a public acceptability problem due to events such as Three Mile Island and the lack of a solution for disposing of the waste.

Legend for the graph: the solid blue line indicates consumption from 1965 to 2013. The dotted blue line indicates projections of energy consumption to 2050 based on the current average rate of yearly increase of 2.9%.

Your mission: Provide nearly enough energy (nearly 7000 million tonnes of oil equivalent) to meet the needs of the United States population in the year 2050 without destroying planet Earth. Reference the data we have looked at throughout this unit!

Figure 1. Example Country Card

Determine solutions to the global energy challenge and potential practices to live sustainably on planet Earth

The students will continue discussion about the various challenges identified in the countries exercise. After this discussion, the students will read an article about the cap and trade policy and debate in small groups the pros and cons of such a policy. A cap and trade policy is one way to limit emissions produced by corporations and industries. An emissions cap is set, typically for CO_2, and if a corporation or industry exceeds the cap they have two remedies available. They can pay a large fine for the additional pollution or they can trade CO_2 credits with corporations or industries that did not reach their cap for CO_2 emissions. The class will split into two groups in order to debate the question "Should a democracy adopt a cap and trade system to limit greenhouse gas emissions?" The groups will be given time to prepare the most compelling reasons for their position; either for or against the cap and trade policy. The groups will then debate the question and as a class we will discuss why the United States did not adopt this policy. Finally, the students will be assigned a one page paper on how the challenges of providing enough energy resources for the globe will impact our ability to live sustainably on planet Earth.

Conclusion

As teachers, we are tasked with preparing students for jobs that don't exist yet, that will use technologies that haven't been invented, to solve problems we don't know are problems yet. High school students of today have grown up in a world of instant gratification and instant access to enormous amounts of information. I feel very strongly that teenagers need to be taught how to think critically and problem solve in order that they are ready to face the challenges of the future. They need to be taught how to sift through the exponential amount of information retrieved with just one Google search. Students need to be able to evaluate information in order to be informed citizens and help solve the challenges that are facing our society. In addition, high school students should be exposed to as many real world problems as possible in order to make their learning relevant and fun. Meeting global energy needs for the future is an excellent topic with which to challenge student's thinking as well as expose them to real world questions and challenges that they as adults will need to solve or at least understand in order to be responsible citizens.

Notes

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(1) "What's the difference between climate and weather?," *National Aeronautics and Space Administration*, September 2014, http://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html#.VCcVCfldWSo

(2) Eugene D. Coyle, Richard A. Simmons, *Understanding the Global Energy Crisis* (West Layfayette, Indiana: Purdue University Press, 2014), 28
(3) David A. Coley, *Energy and Climate Change* (West Sussex, England: John Wiley & Sons, Ltd., 2008), 79, 80
(4) "Energy," *The National Science Digital Library*, September 2014, http://www.shodor.org/interactivate/discussions/Energy/
(5) Hewitt D. Crane, Edwin M. Kinderman, Ripudaman Malhotra, *A Cubic Mile of Oil* (Oxford, England: Oxford University Press, Inc., 2010), 13, 6, 265."BP Statistical Review of World Energy", British Petroleum p.l.c., June 2014, http://www.bp.com/content/dam/bp/pdf/Energy-economics/statistical-review-2014.pdf
(6) Jose Goldemberg, *Energy: What Everyone Needs to Know* (Oxford, England: Oxford University Press, Inc., 2012), 13, 27, 42.
(7) "SWITCH," *SWITCH Energy Project*, 2012, http://www.switchenergyproject.com/index.php
(8) "Ecological Footprint," *Global Footprint Network*, 2014, http://www.footprintnetwork.org/en/index.php/GFN/page/calculators/
(9) "Carbon Footprint," *The Nature Conservancy*, 2014, http://www.nature.org/greenliving/carboncalculator/
(10) "Energy Challenge," *Duke Energy Corporation*, 2014, http://energychallenge.duke-energy.com/
(11) "Global Climate Change," *Deliberating in a Democracy*, 2007, http://www.did.deliberating.org/lessons/global_climate_change.html

Resources

List of Materials for Classroom Use

- Computers, iPads, or access to a computer lab
- Internet access
- Classroom projector
- Large sheets of paper
- Notebook and copy paper
- Drawing tools
- Copies of the cap and trade article
- Copies of the rules for debate

Reading List for Students

Bryson, Bill. *A Walk in the Woods: Rediscovering America on the Appalachian Trail*. New York: Broadway, 1998. Print. An entertaining and educational account of the 2100 mile Appalachian Trail delivered by Mr. Bryson after he walked these miles.

He provides a detailed history of the trail and notes current destruction of the forest and ecosystems. Warning of future destruction and the perils associated with this are also included.

Carson, Rachel, Lois Darling, and Louis Darling. *Silent Spring*. Boston: Houghton Mifflin, 1962. Print. Rachel Carson's classic and passionate look at the destruction of our air, land, and water. First published in 1962, it led to radical changes in environmental laws and regulations

Gore, Al. *An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do about It*. New York: Rodale, 2006. Print. A look at the destruction we are causing on planet Earth due to global warming and a warning about what consequences lay ahead if we don't change our actions now. Written by former Vice President Al Gore, the book was a New York Times #1 bestseller and began the conversation about climate change.

Hiaasen, Carl. *Hoot*. New York: Alfred A. Knopf, 2002. Print. A fictional story about a middle school boy's quest to save owls from the construction of a pancake restaurant in Florida.

Krakauer, Jon. *Into the Wild*. New York: Anchor, 1997. Print. The account of the last months of John McCandless' life as he travels on a spirit quest into the wilderness after rejecting his wealthy lifestyle and upbringing.

Leonard, Annie, and Ariane Conrad. *The Story of Stuff: How Our Obsession with Stuff Is Trashing the Planet, Our Communities, and Our Health--and a Vision for Change*. New York: Free, 2010. Print. An exploration of the dangers of our over consumptive lifestyle and its impact on our health, economy, and environment.

Miller, Arthur I. *Insights of Genius: Imagery and Creativity in Science and Art*. Cambridge, Mass: MIT, 2000. Print. Explores how scientists and artists use creative leaps to answer new questions and further the pursuit of knowledge.

Nash, Roderick. *Wilderness and the American Mind*. New Haven: Yale UP, 1967. Print. An account of American's changing attitudes toward wilderness over history and the birth of the conservation and environmental movements.

Reisner, Marc. *Cadillac Desert: The American West and Its Disappearing Water*. New York, NY, U.S.A.: Viking, 1986. Print. A thoroughly researched history of water resources in the American West and a lesson on the politics and economics of limited resources anywhere.

Seuss. *The Lorax*. New York: Random House, 1971. Print. Dr. Seuss's classic and whimsical look at the dire consequences of environmental destruction.

Wackernagel, Mathis, and William E. Rees. *Our Ecological Footprint: Reducing Human Impact on the Earth*. Gabriola Island, BC: New Society, 1996. Print. A look at

how quickly we are using up resources on planet Earth, especially in developed countries, and how we cannot sustain this lifestyle. An ecological footprint calculator is included with detailed explanations of how we can make positive changes.

Bibliography for Teachers

"Carbon Footprint Calculator." *Free Carbon Footprint Calculator: The Nature Conservancy*. The Nature Conservancy, n.d. Web. 20 Nov. 2014. <http://www.nature.org/greenliving/carboncalculator/>. This site calculates total greenhouse gas emissions either for an individual or a household. Comparison of the user's results is given to the U.S. average as well as the world average.

Coley, David A. *Energy and Climate Change: Creating a Sustainable Future*. Chichester, West Sussex: John Wiley, 2008. Print. This textbook in paperback form is a comprehensive look at climate change, energy economics, and the history of energy use. Numerous case studies and simple numeric problems are included. The international community's efforts to solve the problems of climate change are also discussed.

Coyle, Eugene D., and Richard A. Simmons. *Understanding the Global Energy Crisis*. West Layfayette: Purdue UP, 2014. Print. This book is intended for all audiences but is written with enough detail to satisfy engineers and scientists who are studying the complex issues of energy technologies. It is unique in that it separates energy sustainability from other types of sustainability (environmental, ecological) and discusses the complex interweaving of these concepts.

Crane, Hewitt D., Edwin Max Kinderman, and Ripudaman Malhotra. *A Cubic Mile of Oil: Realities and Options for Averting the Looming Global Energy Crisis*. Oxford: Oxford UP, 2010. Print. Written for anyone interested in global energy issues and potential solutions. The authors discuss the current use of energy resources and debate whether and how these resources can meet future demand. A common volumetric unit, the cubic mile of oil, is defined to better compare consumption and production of various energy fuels.

"Energy Challenge." *Duke Energy - 2050 Vision*. Duke Energy Corporation, n.d. Web. 22 Nov. 2014. <http://energychallenge.duke-energy.com/>. This online game produced by Duke Energy Corporation allows the player to combine different types of energy resources in order to meet consumption needs by 2050. A secondary goal of the game is to help Duke Energy reduce its carbon footprint.

"Energy." *National Science Digital Library*. N.p., n.d. Web. 21 Nov. 2014. <http://www.shodor.org/interactivate/discussions/Energy/>. A mock discussion between two parties about the basic concepts of energy.

"Footprint Calculator." *Footprint Calculator*. Global Footprint Network, n.d. Web. 20 Nov. 2014. <http://www.footprintnetwork.org/en/index.php/GFN/page/calculators/>. This site provides a detailed ecological footprint calculator. Users can also choose aspects of their lifestyle to change and the calculator recalculates their ecological footprint. Suggestions for minimizing impact on planet Earth are also discussed.

"Global Climate Change." *Deliberating in a Democracy –*. N.p., n.d. Web. 21 Nov. 2014. <http://www.did.deliberating.org/lessons/global_climate_change.html>. This resource provides articles for students on global climate change as well as the cap and trace policy. It gives instructions for classroom debate on these issues.

Goldemberg, José. *Energy: What Everyone Needs to Know*. Oxford: Oxford UP, 2012. Print. A basic book in paperback form that details concepts of energy and the information all citizens need to understand.

"Statistical Review of World Energy." *Statistical Review of World Energy*. British Petroleum, n.d. Web. <http://www.bp.com/en/global/corporate/about-bp/energy-economics/statistical-review-of-world-energy-2013/statistical-review-downloads.html>. A comprehensive compilation of immense amounts of data related to global energy consumption and production. All countries of the world are represented. Data can be exported to an excel spreadsheet and a brief overview is also provided.

Tinker, Scott. "Switch Energy Project: a Film and Educational Video Series Dedicated to a Smarter Energy Future." *Switch Energy Project Documentary Film and Energy Expert Video Series*. N.p., n.d. Web. 01 June 2014. <http://switchenergyproject.com/>. This is a non-partisan effort to encourage practical discussion concerning our energy future and the choices that will be involved.

"What's the Difference between Climate and Weather?" *NASA*. N.p., n.d. Web. 20 Sept. 2014. <http://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html#.VG_iOvnF-So>. A brief written description of the difference between weather and climate. Also included is a discussion of why climate needs to be studied as well as maps demonstrating global temperatures. Additional resources for further exploration are listed as well.

Appendix I: Implementing District Standards

This unit will implement the North Carolina Essential Standards for secondary Earth and Environmental Science. These standards require the students to understand climate change, energy resources, and the impacts of these topics on the sustainability of planet Earth. Students will critique the benefits, costs, and environmental impact of various sources of energy. They will also analyze how changes in global temperatures affect the biosphere.

Climate Change

EEn.2.6.1 Differentiate between weather and climate.

EEn.2.6.2 Explain changes in global climate due to natural processes.

EEn.2.6.3 Analyze the impacts that human activities have on global climate change (such as burning hydrocarbons, greenhouse effect, and deforestation).

EEn.2.6.4 Attribute changes to Earth's systems to global climate change (temperature change, changes in pH of ocean, sea level changes, etc.).

Energy and sustainability

EEn.2.8.1 Evaluate alternative energy technologies for use in North Carolina.

EEn.2.8.3 Explain the effects of uncontrolled population growth on the Earth's resources.