# Trades in Action – Powering Our Future

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## Introduction

Most, if not all, students in the 21$^{st}$ century are well versed in the language of technology. They see technology in the form of smart phones, iPads, laptops, tablets, and other ways to access social media. If a group of students are told they do not have access to the school's wireless network on their own device, wait a few days and one or more of the students will have cracked the password to the network and shared it throughout the district. However, we as educators expect that students know how to use technology when in reality, students are proficient in navigating social media but are not adept at using the internet for research and knowing how and where to find legitimate sources for information. Moreover, the newest technological advances related to environmental conservation and sustainability is a mere "brush-over" in the curriculum. These latest technologies are innovations to be used and expanded upon by today's youth in future careers.

At a technical high school, students are focused on a trade for a large portion of their day with the ultimate goal of earning a certificate or license to enter into the work force after graduation. Unfortunately, our academic classes cover the traditional mathematics, science, English, and history topics without incorporating the real-world experiences students might encounter after leaving high school. Students always ask the age-old questions: "how am I ever going to use this" or "why do we have to learn this". Academic courses should include specific examples related to the career options offered in the school. It would make going to science class more interesting and engaging if students were able to see how they would be able to use the knowledge learned.

The students at the high school are highly diverse in their race, ethnicity, socio-economic status, middle school background, and in their special education needs. There are a total of 1,119 students currently enrolled; 48.8% female and 51.2% male. The breakdown of racial diversity is as follows: 61.8% white, 34.0% African American, 1.4% Asian, 0.3% American Indian, 0.2% Pacific Islander, and 2.4% identify with two or more races. Ten percent of the student body identifies their ethnicity to be Hispanic or Latino. Students with free or reduced lunch account for 25.7% of the student body. Twelve percent of the total student body is identified as requiring special education services. Families choose to apply for our technical school for various reasons: the student is learning the family trade, the feeder high school is not considered to be a safe option, or the student does not intend to go to college. Whatever their reason for attending, these students come from all across New Castle County. The technical trades the school offers differ as greatly as the student population does; ranging from nursing to early childhood education, to construction and everything in between. Out of 802 upperclassmen (sophomores, juniors, seniors), 20% study a trade in the Public/Consumer Services cluster, 23% study a Construction trade, 35% study in the Health Career cluster, and 23% study in the Business and Technology cluster.

Many of the students who take Integrated Science in their junior year, study the construction trades as their career path and do not intend to attend a four-year institution post-high school. These students are more likely to join an apprenticeship, begin working in the field, or attend a two-year institution to receive an associate's degree. This junior year course covers the topics of fundamental forces, astronomy, and ecology – containing a small section on alternative energy. Students entering into Environmental Science as a senior choose to do so as an elective course rather than taking Chemistry or Physics. The topics covered need to be authentic, engaging, and provide purpose for the students choosing this course as an elective. This course attracts students from all types of career paths who are looking to graduate and enroll into a 4-year bachelor's degree program, 2-year associate's degree program, apprenticeship, or continue working in the field. This diverse group of students may or may not have a true interest in science but as a teacher, it is my job to connect the course to their future and make them an informed citizen.

Within science education, the standards are in the process of being shifted from the Delaware State Science Standards to follow the Next Generation Science Standards (NGSS). Although intended to be for seniors in Environmental Science, might be in a junior class once a decision is made for which grade level will teach specific standards. The specific science standards and common core standards that will be addressed are detailed in appendix 1 below.

**Content Objectives**

With the completion of this unit, students will be able to:

- Compare the terms renewable resources and non-renewable resources.
- Identify various sources of alternative energy.
- Explain how the global society's needs have changed surrounding energy.
- Compare carbon dioxide emitting energy sources with alternative sources.
- Describe at least one alternative energy source and explain how it relates to a technical trade.

**Essential Questions**

- How has human energy consumption changed over time and what might have prompted these changes?
- What are the alternative fuels currently available to society?

- How can the technical trades be applied to alternative energy sources?
- How does the amount of carbon dioxide emitted vary based upon the fuel source used by society?

**Background**

Student Prior Knowledge

It is assumed students have a working knowledge of the following topics: the main nutrient cycles (water cycle, carbon cycle, and nitrogen cycle); the greenhouse effect and four major greenhouse gases ($CO_2$, $CH_4$, etc…); and electromagnetic radiation. Students have studied the flow of carbon through Earth's systems from being absorbed by plants during photosynthesis to their eventual return to the atmosphere by the processes of cellular respiration and decomposition by both plants and animals, as well as the combustion of plant matter. Both the natural carbon cycle and the impacts humans have had on the carbon cycle have been discussed. It is taught that fossil fuels take millions of years to form under intense temperatures and pressures that exist below Earth's surface. It is briefly discussed that the main ways to extract fossil fuels from the ground are by mining and drilling. These fossil fuels are brought to a plant for combustion where carbon dioxide is eventually released as a waste product. This unit does not cover the energy produced by the combustion of fossil fuels nor are the types of fossil fuels discussed.

It is expected that students have already learned that water; methane, carbon dioxide, and nitrous oxide are excellent at absorbing infrared radiation while in the gaseous state in Earth's atmosphere, which is why they are called greenhouse gases. Students understand that infrared radiation is most commonly experienced as heat from our unit on the electromagnetic spectrum. This infrared radiation emanates partially from Earth's core and partially from the Sun's released energy. Only sixteen percent of the total incoming solar radiation is absorbed directly by the atmosphere while solar radiation originally absorbed by the land and oceans are re-radiated to the atmosphere accounting for an additional fifteen percent of the radiation absorbed by the greenhouse gases.[1] The higher the concentration of greenhouse gases present in the atmosphere; the more infrared radiation can be absorbed. This increase in absorption allows the Earth to warm slightly, even by miniscule amounts. The average global temperature has risen approximately 0.6°C since the beginning of the Industrial Age.[2] Although 78% of the Earth's atmosphere is made up of nitrogen gas ($N_2$) and another 20% is oxygen gas ($O_2$), it only takes a small percentage of the greenhouse gases to absorb enough infrared radiation to prevent an ice age. The greenhouse gases account for a small percentage of the Earth's atmosphere; carbon dioxide makes up slightly more than 0.04% (402 ppm), methane constitutes approximately 0.0002% (2 ppm), and nitrous oxide is even less at 0.00003% (0.3 ppm).[3] Water's concentration in the atmosphere varies due to the cycling of water molecules throughout Earth's biosphere. Students have learned the greenhouse effect is a requirement for life, yet too many greenhouse gas molecules are considered pollution and potentially harmful. The lesson will allow students to identify why there is an increase in the amount of greenhouse gases in the atmosphere and climate change has become a cause for concern over the last few decades.

## Renewable Energy versus Non-renewable Energy

Modern society relies upon non-renewable energy sources to power their everyday life. The term non-renewable as it relates to energy refers to the inability to recover the resource once energy has been harnessed from the source. These non-renewables include coal, oil, natural gas, and nuclear power. Although nuclear power is an alternative energy source, it is still considered to be non-renewable because radioactive elements are unable to be reformed once fission or radioactive decay has occurred. Nuclear is unique because multiple reactions can be used to harness energy, yet after the third generation of radioactive decay, the nucleus can no longer be broken down to elicit additional energy and therefore becomes waste and must be carefully stored. Alternative energy refers to an energy source as anything other than fossil fuels (coal, oil, natural gas) that emit high amounts of carbon dioxide. Renewable energy sources utilize power from replenish able sources such as the sun, the wind, heat from below Earth's surface (geothermal), organic material (biomass), and water (hydropower). These sources do not "run out" over time because they are natural processes and can either be recycled or continuously flow through Earth's systems.

## Energy Change Over Time

Harnessing energy from natural resources, both renewable and non-renewable sources, has been a challenge for centuries. Traditional societies were considered to be energetically sustainable by burning wood and other biomass as their energy source.[4,5] The rate at which wood was burned in these societies could be replenished within a few generations. This is in stark contrast to modern societies where the harnessing of energy, mainly through the combustion of fossil fuels is impossible to replenish on a realistic timescale.[6] Unfortunately, fossil fuels take millions of years to regenerate and therefore once depleted, will not be available for future generations. It should be noted that this depletion is not of immediate concern due to the large amounts of fossil fuel reserves still available underground.

As societies changed and became more industrialized, the availability of different types of fossil fuels also changed based upon the needs of the country. Data was collected from Austria between the years 1830 to 2000. Prior to World War I, most of Austria's energy had been derived from domestic biomass and wood with some coal being imported beginning in the 1850s due to the Austrian industrialization.[7] Much of the once-usable land had either been converted into agricultural land or depleted for energy consumption prior, yet the introduction of fossil fuels allowed many forests to recover.[8] It was not until after World War II that crude oil and natural gas became major imports and were major contributors to Austria's energy portfolio.[9] At this time, post-World War II, Austria relied equally as heavily on fossil fuel imports as is it did on domestic consumption of wood and biomass. It is important to note that foreign trade prior to World War II was solely the import of coal, 8.8 MtC/yr in 1910 making up fifty-five percent of Austria's domestic carbon consumption. This is compared to the six fuel imports making up 23.7 MtC/yr in 2000.[10] Austria's energy requirements grew to unprecedented levels at this time and imports were the only way to keep up with demand.

England's Industrial revolution occurred almost a century prior to that of Austria. The combustion of coal signaled the beginning of England's use of fossil fuels, ignited by the introduction of the steam engine.[11] As technology and energy needs increased across England, so did the demand for coal. The amount of energy accessible through the combustion of coal, 26 GJ $t^{-1}$ of fuel, is less than compared to the other fossil fuels. Natural gas releases 55 GJ $t^{-1}$ of fuel and oil releases 42 GJ $t^{-1}$ of fuel, both releasing more energy than coal. Coal releases the most carbon dioxide (120 t $GJ^{-1}$) when compared to oil and natural gas (75 t $GJ^{-1}$ and 50 t $GJ^{-1}$).[12] Coal became less important in the United States and Europe in the 1900s yet became increasing common in parts of China and India.[13] Even though coal is the greatest contributor to excess carbon dioxide into the atmosphere, most developing nations continue to rely on coal to power their industrialization because of its lower cost compared to the extraction and refining processes oil and natural gas require.

The availability of coal, oil, and natural gas deposits differs between countries across the globe. The majority of oil reserves most commonly used and easily accessible are located in the Middle East with smaller additional oil deposits throughout Australia, Brazil, Canada, China, Sweden, and the United States – however these other reserves are much more costly to extract.[14] The world's annual consumption of oil was in excess of 96 million barrels per day at the end of the third quarter in 2016.[15] Natural gas is becoming more popular as a direct energy source and is predominantly found in Russia with 23% of the world's supply, Iran with 16%, Qatar with 12%, Turkmenistan with 8%, and the United States rounding out the top five countries with 4% of the world's natural gas supply.[16] Natural gas consumption worldwide is expected to increase nearly fifty percent by the year 2030 while the world's dependence on coal diminishes due to the lower amounts of carbon dioxide and increased amounts of energy released by natural gas.[17] Natural gas also produces the least amount of carbon dioxide as a combustion product when compared to both oil and coal.[18] Societies have slowly made the shift from less energy efficient forms of fossil fuel, such as coal, to more efficient natural gas. Although non-renewable and carbon dioxide is still a by-product of its combustion, natural gas releases the most energy in Gigajoules per ton compared to other forms of fossil fuels, and its use represents a positive shift towards decreasing the overall carbon output.

The global energy consumption as of 2014 was 16 terawatts (TW) and continues to increase annually.[19] With readily available fossil fuel resources declining faster than they can be replenished, although accessible for centuries to come, putting too much carbon dioxide in the atmosphere and additional deposits requiring more intensive collection processes and refining, costing more. As the human population continues to climb towards 10 billion by 2050, energy demands are expected to triple.[20] Our fossil-fueled civilization will need to shift towards non-fossil sources of energy, not due to the lack of fossil fuel availability but because of increased extraction and distribution costs and impacts on global climate.[21] However as long as fossil fuel prices remain relatively low, countries will continue to exploit fossil fuels as their predominant energy supply source instead of moving towards alternative energy sources. Renewable resources will become less expensive as the scale of use increases; a higher demand will decrease the cost because it will become more cost-effective to produce.[22] Scientists and engineers have been searching for alternatives. More efficient means of energy conversion are being produced, so although populations continue to grow, the amount of energy consumed does not grow as readily.[23]

The reasoning behind having students understand how society's energy needs have changed over time is to allow students to make connections to climate change and the greenhouse effect; both previously studied topics. Understanding humans' influence on the greenhouse effect will help to underscore the importance of researching and implementing some of the alternative energy sources discussed in the next section. In the greenhouse unit previously studied, students analyze a graph of the Keeling Curve showing the increase of carbon dioxide levels to over 400 ppm. Researchers suggest that if carbon dioxide levels reach 550 ppm, humans will most likely be able to adapt to the changing conditions but many other ecosystems will be adversely affected. If levels are allowed to reach 750 ppm, however the effects could be catastrophic.[24] If our society continues on the current path, these benchmarks will be reached. One of the goals for the unit is for students to study ways in which society can minimize and even eliminate release of carbon dioxide into the atmosphere.

## Alternative Energy Sources

In order to successfully understand the applications for alternative energies, students will need to understand how each of the alternative power sources work and in what conditions energy will be accessible. Solar power, wind power, geothermal, hydroelectric power, nuclear fission, and biomass are the current alternatives to fossil fuels. Although not all renewable resources, each has an overall lower global impact on the addition of greenhouse gases to the atmosphere. As of 2015, renewable energy, as a whole, generated only thirteen percent of electricity for the United States while nuclear power provided twenty percent of the country's electricity.[25] These alternative energy sources only account for thirty-three percent of the electricity, indicating that the United States still depends on fossil fuels as their major source of electricity, heating and cooling, and for the transportation sector. Unfortunately, most of the renewable energy sources require particular conditions that limit their use to specific regions.

Solar power relies on the direct or indirect conversion of solar radiation into electricity. It generated less than one percent of the electricity for the United States in 2015.[26] There are two common ways to capture this energy; through photovoltaic cells as well as solar thermal plants (the use of mirrors to heat water or molten salts). Photovoltaics are accessible anywhere, while solar thermal plants are best suited for areas that receive more direct sunlight; Arizona is a large producer of solar energy. For the purpose of the unit, students will focus on photovoltaics due to their ability to be used for individual locations and on smaller scales. Photovoltaic cells make use of electronically excited electrons of silicon atoms, which produces an electrical current. Slanting the solar panels allows the maximum amount of sunlight to be converted into electricity. One of the shortcomings to solar power is the inability for storage for long periods of time; a back-up power source is still required for extended periods of low solar radiation. Cost is a concern with photovoltaics, not due to the cost of the individual solar cells but due to the required inverter and other electronic equipment needed to convert direct current into alternating current.

An indirect source of solar power is wind energy accounting for 4.7% of the United States' total electricity generation in 2015.[27] Along with the United States, Germany is also a leading country in the use of wind power.[28] Utilizing wind turbines requires a breeze strong enough to move the turbine's blades that can range from small personal turbines to large commercial turbines. An increase in elevation increases the wind speed and modern wind turbines have the ability to be rotated so they always face into the wind. The spinning blades rotate the shaft, which is connected to the generator at the top of the turbine. The generator converts the rotational energy of the turbine blades into usable electricity for the power grid. Wind turbines are best used in locations with ample wind; oceans, mountains, large fields. Aside from geographic limitations, wind turbines have been known to affect the surrounding ecosystems; specifically, in the case of bird and bat populations and the creation of noise pollution.

Geothermal power utilizes the heat from within the Earth to heat or cool water in order to create electricity for the power grid. It can also be used to heat individual buildings. The temperature underground is stable so depending on the temperature differentiation, will determine if the water running through the piping system will be heated or cooled. This is not a widely used source of energy due to its high cost of installation and limited availability across the United States. The best locations for geothermal are those where the warmer temperatures from below the crust seep closer to the surface, typically near volcanoes and plate boundaries like the Ring of Fire on the western coast of the United States and the eastern coasts of many Asian countries. Iceland is the world's leading geothermal producer and is mostly used for heating and cooling homes and businesses.

Out of all the renewable resources, geothermal accounted for the least amount of electricity generated for the United States last year, a mere 0.4%.[29]

Hydropower comes in multiple forms, dams, tidal power, and wave energy, however, the use of large dams is most important for this unit of study because my school is located near a large canal. Hydropower plants are utilized where water flows from an area of higher elevation down to an area of a lower elevation and the water can be temporarily halted on one side of the dam. The amount of energy produced is determined by the volume of water passing through the turbine and the difference in elevation between the two sides of the dam. As water is allowed to flow through the penstock, a turbine is spun that connects to a generator providing power to the electrical grid for human use. A great benefit of hydropower is that it does not create any by-products during its use; however, modern dams are extremely expensive to build and alter the surrounding ecosystem. The Three Gorges Dam in China is the largest hydroelectric dam in the world. The building of this dam displaced over 1.2 million people and endangered hundreds of plant and animal species native to the area.[30] Because water is being built up on one side of the dam, the size of the river will increase in width upstream. This changes the habitats located on the river's edge. It can also affect the migration patterns of many fish species that require the swim upstream to breed as well as the relocation of towns residing near these rivers. Hydropower plants are large enough to distribute energy to many surrounding towns, creating six percent of the United States' overall production of electricity in 2015.[31] Although not very prominent in the United States, hydropower represents eighty-seven percent of renewable power worldwide.[32] The United States has already accessed the major rivers where hydropower would be beneficial without displacing surrounding cities and towns.

Nuclear power generated twenty percent of the United States' electricity in 2015.[33] Even though nuclear is the most common alternative energy in the United States, it only accounts for sixteen percent of the energy produced worldwide from 440 fission reactors in thirty countries.[34] Although sometimes portrayed negatively due to a few infamous reactor meltdowns, this type of energy source is relatively safe. Nuclear reactors use fission, the splitting of radioactive elements – typically uranium, to create energy to be converted into electricity. A major disadvantage to this type of energy generation is that the radioactive waste must be carefully stored. Unlike the previous alternative sources to fossil fuels discussed, nuclear power is considered to be non-renewable because the radioactive isotopes used cannot be rebuilt once fission takes place, so once the reserves have been exhausted there is no way to access more. There is not enough available uranium to scale nuclear power to provide enough energy for the world and therefore the most realistic way to provide enough energy is by using plutonium.[35] Aside from the non-renewable aspect of nuclear power, nuclear power plants are extremely expensive to build and similar to the other alternative fuels, fossil fuels are still the most cost-effective way to access energy.

One of the original sources of energy prior to the use of fossil fuels was that of biomass in its simplest form – burning wood and agricultural biomass. Biomass is used to produce ethanol and other forms of biofuels, electricity, and heat for individual home use. If animal waste is used instead of plant matter, the fermentation process of the waste contributes to the methane production. Unfortunately, methane is a known greenhouse gas that contributes to climate change. More commonly, plant matter is utilized to harness energy; and the burning of organic material releases carbon dioxide as a by-product. It also takes a large amount of biomass to create enough usable energy. The low amount of usable energy is due to the cellulose in the husks of plants and is not easily broken down and therefore energy is not released from the bonds. In 2015, biomass provided the United States with one and a half percent of its electricity.[36]

## Teaching Strategies

### Overview

This unit is designed with two main focuses in mind: to incorporate the school's literacy initiative while simultaneously bringing an authentic and real-world problem into the science classroom. The school's literacy initiative requires students to perform in reading, writing, speaking, and listening at proficient levels that will be partially measured by the SAT. Proficiency is determined by the College Board's benchmarks on college and career readiness. The curriculum unit will challenge students to incorporate their knowledge in their technical trade into a real-world problem of energy consumption and future energy needs. Before knowledge can be applied, students will study the current energy consumption around the world and the various forms of alternative energy sources available today.

A blended learning model will be used to incorporate various components of the lesson to be completed as a large group, small group, and as individuals and will lead students to produce products as a result of the units. Students will have access to the Internet, their career instructor, as well as multimedia resources to assist with the research. Blended learning allows the student to utilize technology, research skills, and face-to-face time to complete the assignments. This lesson is not based around the idea of "I do, we do, you do;" instead a more inquiry based approach with a focus on 21$^{st}$ century skills will be implemented. Blended learning does not mean that the students are on the computers by themselves for the entire unit, direct instruction will be used sporadically throughout the unit to re-group and answer questions, avoid misconceptions, and allow students to participate in discussions.

As a way to organize each of the units, students will find all of the unit requirements posted on our Schoology web site. Schoology is the learning management system used by the school district. This system is used throughout the courses, both Integrated Science and Environmental Science, so students are familiar with the way in which it is used and how content is organized. The unit will be structured electronically with “student completion” rules embedded, requiring students to move through the unit in a particular sequence and complete checkpoints along the way. Environmental Science is taught as a self-paced course with deadlines implemented to practice time management – an important 21st century skill.

When students are presented with more freedom to work then they are used to, they tend to become overwhelmed and unfocused. One way that I have found works to organize and focus students is through the use of a checklist. A sample checklist for the Background Unit is available under appendix 2. I only include graded items on the checklist and therefore you will not see the points in which a class discussion takes place or students are previewing the vocabulary terms. The icons are from Schoology to aid students in identifying what item they are to be looking for.

The three units will be structured by providing background knowledge in the first unit, individual application based upon research in the second unit, and application to a rea-world scenario in the third unit. The units build upon the successful completion of the unit prior. In order to be successful at understanding how a technical trade relates to an alternative energy source, students must be knowledgeable of the different types of alternatives and the importance of completing this unit. In order to produce a meaningful product for the real-world scenario, students must comprehend how the technology works and how the technical trades can impact their installation and maintenance. This unit is designed to demonstrate why students study a technical trade and the applications into future technology.

**Classroom Activities**

Activity 1: Background Unit

This unit will be used as a mode to gain background information on fossil fuels, alternative energies, and current energy consumed, in order to be used in finding connections between what students’ study in their trade and this current technology. The structure of the unit will be as follows: a brief introduction to the topic will be provided by the instructor in either written or verbal form, key vocabulary terms for students to preview, the science standards being addressed in the unit, a close reading activity based upon the different alternative energy sources, a brief video with questions, and an opportunity to analyze graphs and data to apply what they know. This section of the unit will provide students with required background knowledge that will be applied in the second and third activities of the alternative energy unit. The teacher should be prepared to discuss as a class the different types of alternative energy sources, how they each work, where they work best, and any advantages and disadvantages. The class discussion must also review the difference between renewable and non-renewable, the difference between fossil fuels and alternative fuels, and the role carbon dioxide plays.

The incorporation of literacy – reading, writing, listening, and speaking – is imperative to support our school's initiative. Students will be using the reading skills during the close reading assignment where they will need to answer text dependent questions. During the research phase of the unit, students will be implementing their reading comprehension skills to extract appropriate information that will be applied to their specific topic based upon their chosen course of study at the school in the second activity. Listening skills will be addressed as students watch the required video and answer specific questions based upon the content of the video. The remaining two activities of this unit will continue to support the literacy initiative of the high school.

Activity 2: Technical Trade Application

The second research activity is centered on how the student's career area fits in with harnessing a renewable energy source, and a finished product or presentation to display the student's findings. Students will look at a global scale of energy needs, how energy consumption has changed over time, and how we, as a society, need to modify where our energy comes from based on climate change, which had been studied in the unit prior. The goal is for students to make connections between current technologies and their future career aspirations and describe the impact this technology does or could have on society if it was more widely used. Some examples that have been used for a smaller-scale project in my class include: electrical trades have a vested interest in the installation of solar panels and the engineering of electric vehicles, our HVAC program has a basic understanding of the piping and energy transfer required for geothermal heating and cooling, carpentry has been interested in building a wind turbine and using electrical trades to help build the motor but they might also be interested in how to build a green home or business using sustainable materials or saving the customer money with a sustainable design, and automotive technology students focus on the racecars developed to only use alternative fuels such as biodiesel, hydrogen gas, or electric. Student achievement should improve because students will be studying current global issues and new technology that continues to develop and might interest a new career path.

To support literacy in the second stage of the unit, writing and speaking will be addressed in this finished product for many students. Students will be given the option to either write an essay explaining their findings or create a visual presentation in the form of a PowerPoint, Prezi, or website. Periodically throughout the weeklong project students will share out their findings with their peers and with the teacher to practice expressing their knowledge as well as have a reflective period. All students will be expected to present their topics, regardless of whether they chose to write an essay or create a visual product to represent their research. The purpose of this performance task is for students to begin to understand that energy consumption and the excessive release of greenhouse gases is a global dilemma that they have the ability to change.

Activity 3: Real-world Scenario

The third major part of this unit will be an activity named "SG Goes Green". Teams of three to five students will be asked to incorporate alternative energy sources into the current design of our school building. The scenario that teams will be posed with at the start of the assignment is that the school is looking to build a swimming pool on the property but must fund the project with the money saved from their electric bill. See appendix 3 with the sample letter provided to each team. This project will require students to identify the best option(s) for energy sources based upon our location and the energy consumption needs of the building. Students will be provided with recent energy usage statistics as well as how much is spent per month on electricity (see Figure 1 below). They will also have access to the building dimensions and property size (see figure 2 below). The teams will create a PowerPoint presentation identifying the renewable energy source(s) they feel will best benefit the school, advantages and disadvantages of choosing this energy source, creating a spending budget based upon parts only (labor is expected to be completed by the career areas of the school), and how long it will take the school to pay off the energy source before it can afford to install the swimming pool. At the end of the presentation, teams must identify which career areas will be asked to install various aspects of the project – this will be made easier after the technical trade application assignment has been completed. It will be helpful to group the teams to incorporate a mixture of career areas to bring a multitude of perspectives to the team. See appendix 4 with student directions and appendix 5 with the rubric.

As future business associates, students will have to create an estimated budget for the project and identify all of the career areas available in the school that will be assisting them based upon the chosen energy sources. Teams must identify the location for the alternative power to be built on the school property and explain their reasoning behind these decisions. To assist with the research of the project, teams will visit some of the construction trade shops to provide additional understanding. Our electrical trades instructor has a solar panel and is able to demonstrate the amount of energy that is lost when even a portion of the panel is covered by shade. The HVAC instructor has a piping system and is able to show the heating and cooling of a system that would be built underground. Students are encouraged to ask the instructors questions associated with labor hours, cost of installation, and additional questions to aid in their understanding of the alternative energy source. The finished product will be presented out to showcase student knowledge, understanding, and application.

| Months 2012-2013 | SCHOOL'S Energy Usage (kWh) | SCHOOL'S Energy Cost |
|---|---|---|
| July | 145,187 | $13,598.27 |
| August | 169,625 | $15,155.86 |

| | | |
|---|---|---|
| September | 233,539 | $22,005.30 |
| October | 225,843 | $20,531.14 |
| November | 210,476 | $19,245.58 |
| December | 209,948 | $19,314.81 |
| January | 215,100 | $19,683.08 |
| February | 220,880 | $19,972.72 |

Figure 1. The amount of energy used in kWh and the overall cost for each month between July 2012 and February 2013.

| **Construction facts: Entire property** | **Construction facts: Instructional space** |
|---|---|
| Property Total: 113 acres | Technical Trades Sq/ft: 61,698 |
| School Footprint: 7 acres | Instructional (Classroom) Sq/ft: 39,497 |
| | Total school Sq/ft: 254,576 |

Figure 2. Property size of the building, complete school grounds, and square footage used for instructional space including regular academic classrooms and technical trade rooms.

**Student Resources**

Background Unit Resources

Video: Renewable Energy 101 – by Student Energy
https://www.youtube.com/watch?v=T4xKThjcKaE This video provides the students with a brief description of renewable energy sources and the difference between renewable and alternative.

Video: Renewable Energy – by Bozeman Science
https://www.youtube.com/watch?v=B8WuEyL-YNY This video is an excellent overview of renewable and non-renewable resources and briefly explains why society has not moved away from fossil fuels. The video discusses the six different types of alternative fuels (biomass, hydroelectric, solar, geothermal, wind, and hydrogen).

Article: Energy, Environment, and Our Future: Global Energy Consumption https://www.e-education.psu.edu/earth104/node/1347 Students will be provided with the first two graphics from the webpage and be asked to identify cause and effect between the population and the amount of energy consumed. Students should be able to identify the relationship between increased world population and increased energy consumption. The teacher may need to encourage the students to think about what was taking place in the world when the energy need increased – World War II had ended. After having watched the video (previous link) students should be able to identify the disproportionate usage of non-renewable fossil fuels to renewable resources.

Article: Advantages and Disadvantages of Energy Sources http://homepages.spa.umn.edu/~larry/ADVANTAGE_DIS_ENERGY.pdf Students may be able to use this document to help identify advantages and disadvantages of each fuel source.

Textbook: SEPUP: Science and Sustainability – 31.2 This chapter is a great article touching on each of the alternative energy sources, providing background and advantages and disadvantages. Our school had purchased these textbooks for the Environmental Science course. The link below is another article (Fossil Fuels vs. Renewable Energy Resources by Eric McLamb) that can be used in place of the text book. http://www.ecology.com/2011/09/06/fossil-fuels-renewable-energy-resources/

Real-world Scenario Resources

If you choose to use this lesson, check with your school district to access energy consumption data and costs to make it a real-world challenge for your school. The data in figures 1 and 2 are for my school.

**Appendix 1**

NGSS Standards

HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
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.

Common Core Literacy Standards

CCSS.ELA-Literacy.WHST.11-12.2.e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).
CCSS.ELA-Literacy.WHST.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
CCSS.ELA-Literacy.RI.11-12.7. Integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.

**Appendix 2**

# Alternative Energy Assignment List

This folder is due ___________________

| | ASSIGNMENT TITLE | FOLDER LOCATION | |
|---|---|---|---|
| | Video Assignment | Ecology → Alternative Energy → Unit 1 | |
| | SEPUP 31.2 – Reading and Questions | Ecology → Alternative Energy → Unit 1<br>*Article on PAPER* | |
| | Graph Analysis | Ecology → Alternative Energy → Unit 1 | |

***This unit will supplement the next two units on Alternative Energy.***

**Appendix 3**

**Letter from the Principal** (given to each team)

April 12, 2016

To Whom It May Concern:

I am coming to your contracting company because St. Georges Technical High School is looking to lower its energy costs to afford an outdoor swimming pool for a swim team in the year 2020. The goal is to incorporate alternative energies into the existing building but the school would like your guidance to determine the best course of action.

If you could draw up a business plan, produce a final sketch, and provide an overall cost before Monday, April 25, 2016; we will discuss your plan at that time. Our goal is to begin working on the project at the end of the 2018-2019 school year.

Sincerely,

Principal

St. Georges Technical High School

**Appendix 4**

**Project:**

Your goal is to design a new and improved St. Georges that includes the use of different types of alternative energy. You will use the current building with the addition of alternative power sources.

Your group will begin by researching the various types of alternative energy sources: **solar, wind, biomass, hydroelectric, geothermal, and hydrogen fuel cells**. Base your ultimate decisions on which source(s) have the most advantages and least amount of disadvantages for our school. You may use up to, but not exceeding, 3 different types of alternative energy sources.

Use websites that end in .edu; .gov; .org

Your contracting company will use the current data for the school's energy output to determine if your plan to conserve energy will be successful. This data should be included in your final presentation.

You will use fellow St. Georges future employees to put your plan into action.

You will present your business plan to a board on Monday, April 25th. You should have:

- Business plan with budget
- Sketch of building with location of energy sources
- PowerPoint presentation discussing your plan (convince Mr. Reynolds to use your contracting company) How can your company save St. Georges enough money to purchase the swimming pool? Include the strengths and weaknesses of the alternative energy, how it works, does it need to be located in a specific area, what "outside companies" (SG shops) are you going to use and how are you going to utilize their skills?

**Appendix 5**

Group name:

| Component | 3 | 2 | 1 |
|---|---|---|---|
| What is the goal or mission of your company? | Mission for the company is specific and clearly explained – how they plan on helping SG | Unclear as to the mission of the company<br>OR<br>Lacks specifics as to how plan on helping SG | No indication as to how the company will help SG |
| Explanation of Alternative Energy(ies) | Clearly explains advantages and disadvantages for each type of energy | Attempts to explain advantages and disadvantages but information is unclear<br>OR<br>Includes detail only on one – adv. or disadv. | Lacking details about both advantages and disadvantages |
| Budget/Costs – How long will it be paid off? | Provides a list of purchases as well as estimated time frame to cover any cost | Lacking either complete list of purchases or estimated time frame to pay off debts | Lacking sufficient evidence of costs<br>OR<br>Budget contains costs unaccounted for |
| Cooperating Shops | Detailed description of how each shop area was used for the project | Names but does not describe shops assisting in the overall plan<br>OR<br>Does not explain how all of the shops used will help, only explains some of the shops used | Lacks descriptions for how each career area will be utilized |

Notes:

How convincing was the group? Would you consider using this company?

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1 Smil, Vaclav. 2006. "Energy: A Beginner's Guide." Oneworld Publications.

2 Lincoln, Stephen F. 2005. "Fossil Fuels in the 21st Century." *A Journal of the Human Environment* (Royal Swedish Academy of Sciences) 34 (8): 621-627. doi:http://www.bioone.org/doi/full/10.1579/0044-7447-34.8.621.

3 NASA. n.d. *Climate Science Investigations.* Accessed 11 8, 2016. http://www.ces.fau.edu/nasa/module-2/how-greenhouse-effect-works.php.

4 (Smil 2006, 103)

5 Erb, Karl-Heinz, Simone Gingrich, Fridolin Drausmann, and Helmut Haberl. 2008. "Industrialization, Fossil Fuels, and the Transformmation of Land Use: An Integrated Analysis of Cabon Flows in Austria 1830-2000." *Journal of Industrial Ecology* (Blackwell Publishing) 12 (5/6): 686-702. Accessed August 2016. doi:10.1111/j.1530-9290.2008.00076.x.

6 (Smil 2006, 103)

7 (Erb, et al. 2008, 692, 696)

8 (Erb, et al. 2008, 686)

9 (Erb, et al. 2008, 692)

10 (Erb, et al. 2008, 691-692)

11 (Smil 2006, 108)

12 (Lincoln 2005, 624)

13 (Smil 2006, 117)

14 (Lincoln 2005, 622)

15 U.S. Energy Information Administration. 2016. *Short Term Energy Output.* December 6. Accessed December 8, 2016. http://www.eia.gov/outlooks/steo/report/global_oil.cfm.

16 Central Intelligence Agency. n.d. *The World Factbook.* Accessed December 13, 2016. https://www.cia.gov/library/publications/the-world-factbook/rankorder/2253rank.html.

17 Hedberg, Dick, Sven Kullander, and Harry Frank. 2010. "The World Needs a New Energy Paradigm." *A Journal of the Human Environment* (Royal Swedish Academy of Sciences) 39: 1-10. Accessed August 2016. doi:10.1007/s13280-010-0057-9.

18 (Lincoln 2005, 624)

19 International Energy Agency. 2016. *Key World Energy Statistics.* Accessed December 13, 2016. https://www.iea.org/publications/freepublications/publication/KeyWorld2016.pdf.

20 Lewis, Nathan S. 2007. "Powering the Planet." *Engineering and Science*, 12-23.

21 (Smil 2006, 105)

22 Keles, S. 2011. "Fossil Energy Sources, Climate Change, and Alternative Solutions." *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects* 1184-1195. Accessed July 14, 2016. doi:10.1080/15567030903330660.

23 (Lewis 2007, 16)

24 (Lewis 2007, 18)

25 Begos, Kevin. 2016. "Solar Energy Controversies." *CQ Researcher* (CQ Press; SAGE Publications, Inc.) 26 (17): 385-408. Accessed July 14, 2016.

26 (Begos 2016, 389)

27 (Begos 2016, 389)

28 (Hedberg, Kullander and Frank 2010, 4)

29 (Begos 2016, 389)

30 Hvistendahl, Mara. 2008. "China's Three Gorges Dam: An Environmental Catastrophe?" *Scientific American.* Accessed December 11, 2016. https://www.scientificamerican.com/article/chinas-three-gorges-dam-disaster/.

31 (Begos 2016, 389)

32 (Hedberg, Kullander and Frank 2010, 2)

33 (Begos 2016, 389)

34 (Hedberg, Kullander and Frank 2010, 3)
35 (Lewis 2007, 19)
36 (Begos 2016, 389)