Sustainable Energy and Society: A Scientific Apology for Energy Reform

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This Curriculum Unit is recommended for:
IB Chemistry I & IB Chemistry II (Standard or Higher Level), Grades 11 – 12

Keywords: Energy, Alternative, Renewable, Non-Renewable, Solar, Solar Cells, Nanotechnology, Dye-Sensitized Solar Cells, Electrochemistry, Galvanic Cells, Chemical Reactions, Electricity, Nanoparticles, Climate Change, Energy Usage, Consumption

Teaching Standards: See Appendix 1 for Teaching Standards addressed in this Curriculum Unit.

Synopsis
The pursuit for clean sustainable energy will continue to dominate the twenty-first century and the sprint to conquer a cleaner society will steadily increase as resources are depleted at an astonishing rate. The following Curriculum Unit will not only give an overview of the present energy systems but will also look at where we will find energy in the future – will it be the use of cleaner fossil fuels or renewable energy sources? As the United States entered into the Paris Agreement in September 2016 [1] and President Obama took a stand and agreed to fight climate change and reduce emissions, the fight for a cleaner climate is now a national fight. The purpose of the Curriculum Unit is for students to gain an understanding of Renewable and Non-Renewable Energy and use the information learned in various types of informal and formal assessments. Students will be prompted with visual projects, case and situational studies, and laboratory applications by building an Electrochemical Cell and Dye-Sensitized Solar Cell. At the end of the Curriculum Unit, students will have analyzed the various types of energy and the advancement of renewable energies with the growth of nanotechnology and nanoparticles.

I plan to teach this unit during the coming year to 36 junior-level and 21 senior-level students in IB Chemistry I & II, Higher-Level.

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Joseph Peter Peltack, III

Rationale Behind Curriculum Unit

"On the morning of Sept. 9, an inspector with the Alabama Surface Mining Commission was performing a routine monthly check of an old coal mine in Shelby County [Alabama] when he noticed 'a strong odor of gasoline' as well as a sheen on the surface of one of the retention ponds"[2] The strong odor and sheen on the pond was found to be a leak from an underground pipeline located in the Shelby County Wildlife Management Area that sends out approximately 1.3 million barrels of gasoline per day along the east coast. The pipeline supplies the east coast with 40 percent of their gasoline supply and it was estimated that at the time of the spill more than 336,000 gallons of gasoline were lost. As Alabama worked to pinpoint the location of the spill and recover from the economic and environmental damages, Americans across the southeast, stretching from Western Texas to New Jersey, felt the effects of the spill – surging gas prices, gas stations temporarily out of service, and six states declared a State of Emergency due to the temporary loss of gasoline until the pipeline was repaired.[3] While the pipeline spill in Alabama is only one instance of an environmental disaster, there have been numerous disasters in the United States alone that outrage environmentalists and increase pressure to our government officials to seek better and more environmentally-friendly methods of obtaining and sustaining energy for society.

As science, technology, and society progresses, so do the fields of energy and the downright necessity for cleaner and longer-lasting energy sources. From the basics of High School Environmental Science Classes, nonrenewable resources are being consumed at an astonishing rate by first-world countries and the cry for efficient energy sources is continually heard around the world. This academic year, my IB Chemistry students will be studying Energy (Environmental Chemistry) as an addition to the IB Curriculum. While there were other options to choose from (Material Science, Biochemistry, Medicinal Chemistry) for the optional topic, Energy as a topic is one that is socially and scientifically intriguing and relevant as society, technology, and science progresses. My hope is to expose my students to the holistic approach of energy development, from basics to most complex structures of energy infrastructure and dependency. Through the Curriculum Unit, students will fine-tune skills that have been visible through the course and gain new analytical and developmental skills by delving into content that is not often studied in a Chemistry Course. Through the Curriculum Unit, my professional goal is to close the gap on IB Exam Scores, specifically the portion of the exam that focuses on the assessment of the IB Chemistry Optional Topic.

Demographics of the School

Myers Park High School (MPHS) is one of the 160 public schools in the Charlotte-Mecklenburg School System and houses approximately 3,000 students in grades 9-12, one of the largest public schools in North Carolina. MPHS sits on 62 acres and contains 13 individual academic buildings, which transforms a high school campus into a small community college-like environment. After graduating from MPHS, approximately 94% of the students go on to pursue their education: 81% attending a four-year college or university, 13% attending a community or technical college, and the remaining 6% join the work-force or military (per the Profile of the Class of 2015). MPHS is home to the first public International Baccalaureate (IB) Diploma Program in North Carolina and first Middle Year Program (MYP) in the United States.[4]

The International Baccalaureate (IB) Program is the most rigorous academic option that is offered at MPHS for students who are in Grades 11 and 12. The curriculum the students receive prepare them for post-secondary studies, with many of the students placing out of first-year college classes due to earned credits through IB Examinations. Students who participate in the IB Program work to receive their IB Diploma, which requires the successful completion of one course from each of the six IB Subject Groups: Studies in Language and Literature, Language Acquisition, Individuals and Societies, Sciences, Mathematics, and the Arts[3]. The IB Courses offer students the opportunity to learn college-level curriculum while preparing for college-level rigor in the duration of high school. With 46 IB Courses to choose from, students are able to create a schedule that explores their interests and passions, learn new skills in each of the classes, and learn and apply skills that are necessary for success in the post-secondary setting.

I currently teach on a 4x4 schedule, rotating between an A- and B-Day Schedule. I teach two sections of MYP Chemistry, one section of IB Chemistry I (Junior Year), and one section of IB Chemistry II (Senior Year). The IB Program is structured by the International Baccalaureate Office with curriculum syllabi updated every five years and testing schedules and data released yearly. While the IB Program releases guidance on the instruction of each subject area, teachers are given free-range with how the curriculum is delivered and an expectation of rigor and excellence, at a minimum, is expected throughout the program. In IB Chemistry, a standard of high-expectations for academic performance, an environment of free-discussion and continual questioning of ideas, and a rigorous class structure is set to ensure students are understanding the content, receiving it at a higher-ordered level of thinking, and making connections between curricula and real-world applications. Throughout the two years students take IB Chemistry, my classroom is structured to increase in rigor, but also in independence. While there are certain topics that must be explored inside the classroom, much of the essential learning occurs outside the classroom through instructional videos and guided practice, and then my students return back to the classroom for a deeper understanding through problem sets, societal application case studies, or laboratory experiments. The benefit of this structure is to provide students more in-class time to see the science, do the science, and fully understand how it functions rather than hearing about it in a 90-minute lecture every other day.

During May of the Senior Year, IB Chemistry students take their final examination, which is broken down into three papers. As students complete their IB Examinations and Assessments, the program releases data on the exam cycle for that year, giving teachers not only student scores, but also the strong and weak sides of both the subject test and external assessments. Using previous years' data and general trends in the IB Curriculum post-collaboration with other IB Chemistry Teachers, the weakest part of the IB Curriculum is Paper 3, which focuses solely on the optional topic. While students understand the Higher Level Chemistry Curriculum, they struggle with the optional topic, reasons being the curriculum for the selected topic is too hard to understand, the optional topic is not covered completely, or students simply pass on the information because the material is selected by the teacher. After receiving the feedback from the previous testing cycle, my Curriculum Unit shifted to focus on Energy in Society and how the development of alternative energy is shaping the energy profile of the 21st Century.

Objectives of the Curriculum Unit

Starting in the 1960's, university and secondary educators worked to create the curriculum, syllabi, and examinations for the IB Program and is still managed by the IB Diploma Program[5]. The expanded timing of the course allows for richer academic discussions, inquiry-based instruction, and laboratory experiments. IB Chemistry has 11 required topics as well as one optional topic that is selected from four options. Refer to Appendix 1: Teaching Standards for the details of the objectives for the Curriculum Unit.

Content Research

Being Forced into Energy Independence?

The year was 1977 and Jimmy Carter was recently elected President of the United States. Carter entered the Presidency during an economically and internationally turbulent time for the USA, following Richard Nixon and Gerald Ford and taking on the aftermath of the Oil Embargo of 1973.[6]

> During the 1973 Arab-Israeli War, Arab members of the Organization of Petroleum Exporting Countries (OPEC) imposed an embargo against the United States in retaliation for the U.S. decision to re-supply the Israeli military and to gain leverage in the post-war peace negotiations. Arab OPEC members also extended to embargo to other countries that supported Israel including the Netherlands, Portugal, and South Africa. The embargo both banned petroleum

> exports to the targeted nations and introduced cuts in oil production. Several years of negotiations between oil-producing nations and oil companies had already destabilized a decades-old pricing system, which exacerbated the embargo's effects.[7]

The Oil Embargo of 1973 led to the formation of various government departments and laws being enacted in order to safeguard our energy future – America faced a problem and our solution was simply to become more independent of foreign countries for our fuel. Fast-forward a few decades and America still relies on the import of foreign fuel to power our cities and cars but our independence has grown since the early 70's. As the Department of Energy has grown over the past few decades, so has their focus for the United States. Originally formed to find various energy sources,[8] the Department of Energy has focused on nuclear weapons research and the clean-up associated with nuclear weapons and is now focusing on the challenges associated with non-renewable resources and the development of science and technology for renewable resources. "The Department has sought to transform the nation's energy system and secure leadership in clean energy technologies, pursue world-class science and engineering as a cornerstone of economic prosperity, and enhance nuclear security through defense, nonproliferation, and environmental efforts."[9] While we [Americans] are producing our own electricity and growing our oil production, there is a greater cry for cleaner energy due to environmental disasters as described most recently in Alabama. More recently, the world has seen the effects of the overuse of non-renewable energy with resources slowly depleting and countries often struggling to maintain fossil fuel usage. As coal, petroleum, and natural gas dominated the 19th- and 20th-centuries, the late-1980's saw the creation and increased usage of alternative energy. As of 2014, "the renewable share of energy consumption in the United States was the highest (nearly 10%) since the 1930's, when wood represented a larger share of consumption."[10] Based on recent data, Americans produce and consume some of the highest amounts of energy and the damage to the environment is a cry that many environmentalists are speaking out against, which increases the demand for cleaner and more efficient alternative energy. A fundamental issue within the energy market that is continually raised is the role of the government. The stark difference on both sides is viewing the governmental policies and interventions as an advancement to our society or a necessary evil that needs to be restricted for free market development and trade. As environmentalists across the globe stretch far and wide to seek out a cleaner tomorrow, the national governments are working together to reduce emissions, increase production of alternative energy, and diligently working to turn back the clock on the damage done to the environment. From the Kyoto Protocol to the Paris Agreement on Climate Change, governmental agencies are working to ensure the world in which we live now is the same, if not better, compared to the one future generations will live in the future. "Energy policy in the United States has focused on three major goals: assuring a secure supply of energy, keeping energy costs low, and protecting the environment. In pursuit of those goals, government programs have been developed to improve the efficiency with which energy is utilized, to promote the domestic production of conventional energy sources, and to develop new energy sources, particularly renewable sources." The most recent step for the United States was signing the Paris Agreement on Climate Change, which has a long-term goal of keeping the global average temperatures to below 2^{o}C above the pre-Industrial Revolution Levels, as well as using the most efficient science and technology to reduce emissions before the end of the century.[11] While the United States was slow to ratify the Agreement, President Obama's signature signaled our country's dedication to reduce our emissions by dedicating scientists and technology to combat the global environmental destruction and continually monitor the progress of those countries involved in the agreement.

Each month, the U.S. Energy Information Administration releases a Monthly Energy Review (MER) which is a "publication of recent and historical energy statistics. This publication includes statistics on total energy production, consumption, and trade; energy prices; overview of petroleum, natural gas, coal, electricity, nuclear energy, renewable energy, and international petroleum; carbon dioxide emissions; and data unit conversion values."[12] In order to understand the energy sector for the United States, dissecting and analyzing our energy profile is important to determine not only the production and consumption of our country but to also set the stage for the development and usage of nanotechnology in the energy sector.

Over the previous 100 years, the development of energy in the United States has taken a drastic turn in development and has impacted the environment most recently in a negative manner. A various range of sources has been used to produce electricity. Coal, for many years, supplied over half of the electricity that the nation used, but has taken a decline in recent years. While coal has declined in usage, natural gas rose in usage and was met with equal concerns about global climate change regarding coal and natural gas usage. As concerns turned into governmental legislation for cleaner energy, different energy sources began to spring into existence. Nuclear Fission supplies about 20%, hydropower less than 10%. Petroleum, which was an important generating fuel in the 1970's and early 1980s, now contributes less than 1% of electricity generation. A surge of construction of wind-powered generating capacity has brought its share of total generation to almost 5%.[13] As society grew with a population increase, the cleaner energy field has increased as well. The advance of society has opened doors for the improvement of our energy sources, but has left a gap in our atmosphere.[14] Due to the increase of greenhouse gases in our atmosphere and the depletion of the ozone layer, the search for alternative energy has been a front-runner for society and will continue to dominate the 21st-century until society takes a stand against polluting the atmosphere.

The biggest concern with energy in the United States is the amount that is used by Americans, regardless of the sector in which it lies. "In 2013, world total primary energy consumption was about 543 quadrillion British Thermal Units (Btu), and U.S. primary consumption was about 97 quadrillion Btu, equal to 18% of world total primary energy consumption"[15] The United States, regardless of size of the country, consumes nearly twenty-percent of the world's energy. The following graphs depict the energy usage based on sectors and the types of energy used by the United States. All graphs and data was obtained through the Monthly Energy Review from the U.S. Energy Information Administration.[16]

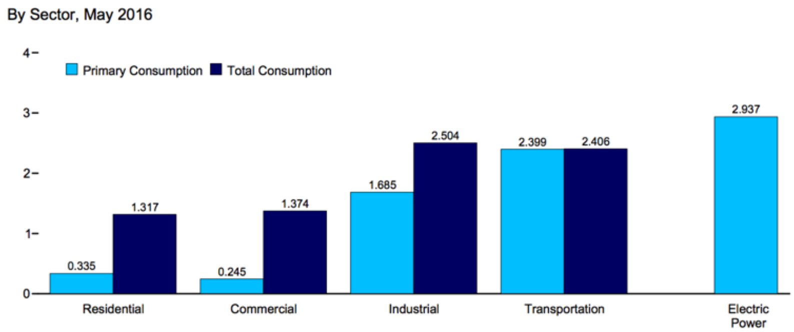


Figure 1
Energy Usage of the United States, by Sector Measured in Quadrillion Btu

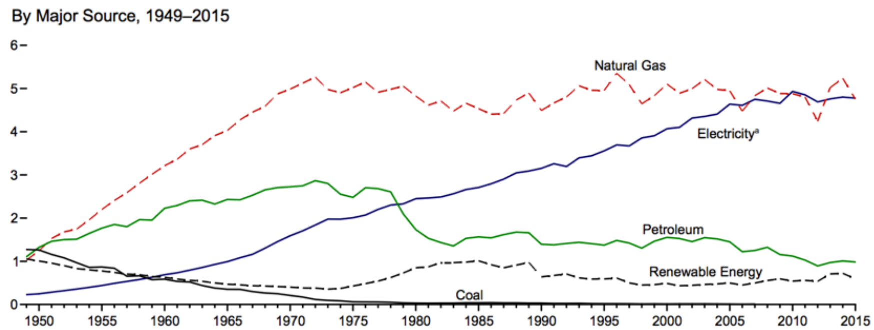
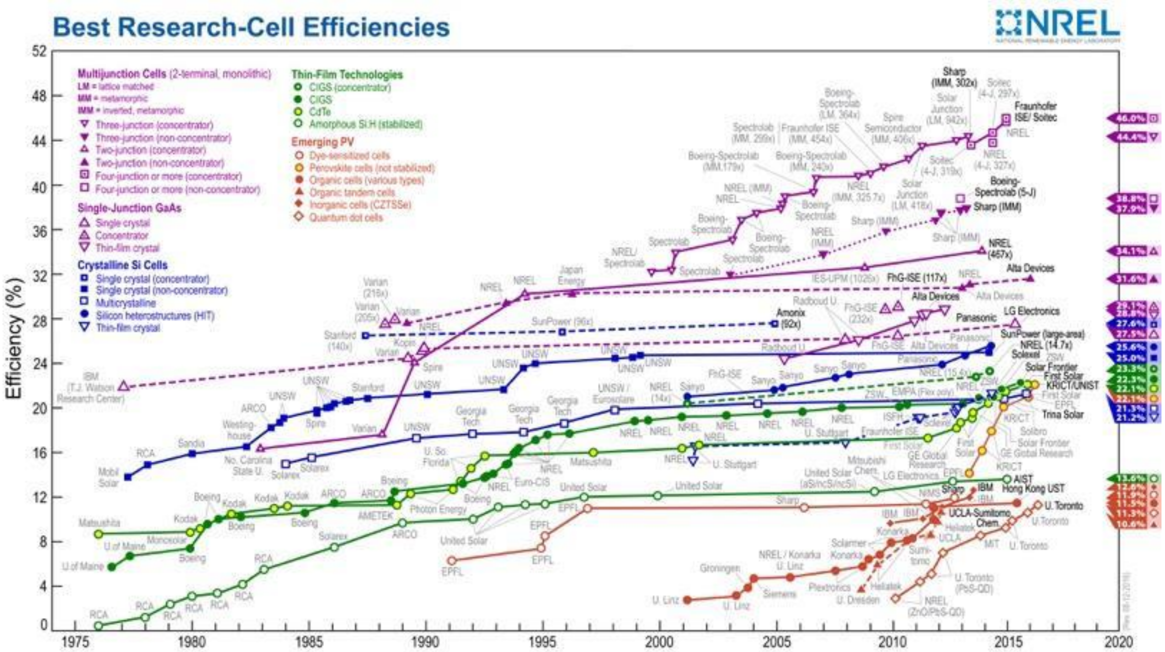


Figure 2
Residential Sector Energy Consumption Measured in Quadrillion Btu

A solar cell is an electrical device which, in its basic nature, converts the light from the sun into energy using the photovoltaic effect. Simplistically, a solar cell has to have a material which will absorb the solar energy in the form of a photon, excite an electron to a higher energy state (by increasing the amount of energy the electron contains), and force the electron into the circuit for the creation of the energy. Using silicon (Element 14 on the Periodic Table) is the main material which is used for a solar cell because of its abundancy in the environment, its cheap cost, and its efficiency in the solar cell.[17] Using a solar cell most recently has caused an increase in the field of alternative energy and has also led scientists and government officials if there is a better way to make solar cells. “EIA expects that utility-scale solar capacity will grow by about 13.3 gigawatts (GW) in 2016 and 2017 combined. The projected increase would bring the amount of solar capacity at the end of 2017 to 26.8 GW, almost double the total amount of capacity existing at the end of 2015 (13.5 GW). States leading in utility-scale solar capacity additions are California, Nevada, North Carolina, Texas, and Georgia.”[18] The question that is now posed is if solar cells can be made more efficient, but at a lower cost. The biggest upside about using silicon is the cost and abundancy – at a lower cost and higher abundancy in the environment, it makes building a solar cell much easier. Using nanoparticles inside a solar cell increases efficiency, but the cost of using a nanoparticle is well beyond what a typical citizen could afford and is only used in governmental research. The below image[19] shows the different types of solar cells and their efficiency.

Highlighting the purple lines (Multijunction Cells) shows an increase in efficiency. It is within these data ranges where nanoparticle solar cells lie. As particles are used to coat the solar cells, an increase in efficiency takes place, making the solar cells convert more of the captured solar energy into electrical energy. Throughout the Curriculum Unit, the students will learn about the efficiency of using nanoparticles in solar cells and the cost behind the efficient technology.



Take the city of Burlington, Vermont; in 2015, it became the first city in the United States to run completely off alternative energy.[20] “The city lives up to that mission by acquiring its energy in diverse ways, including biomass, hydroelectric, solar and wind. Its biggest power generator is hydro, which the city acquires from dams both locally and elsewhere in the region.”[21] The simplicity in knowing a city that can convert to completely alternative energy gives hope to the country that if one city can do it, so can many others. The future of energy in the United States is a clear path, one that leads to the saving of our ozone layer and our energy dependency.

Instructional Implementation

Strategies

During the Curriculum Unit, the following teaching/classroom strategies will be utilized:

Student Project Teams and Interactive Technology

To begin the Curriculum Unit, students will be assigned a visual project, which will allow them to work together in comparing and contrasting the various types of energy, both renewable and nonrenewable, to determine the effects on the environment and if the type of energy is a suitable source of energy for society. Student Project Teams allow for the collaboration of various levels of content knowledge and the growth of information processing from individual students. The visual project will also allow the students to collaborate on the use of technology in the classroom. While the term visual project is a free definition, the students will be asked to use technology to research and present their projects through the course of the Curriculum Unit. As well, since most of the unit focuses on the infrastructure and development of solar energy, students will research, collaborate, and present on solar cell as a source of energy, both pros and cons, as well as the development of the technology.

Laboratory Skills

The Curriculum Unit will provide students with two opportunities to utilize previous learned laboratory skills in the application of Alternative Energy, specifically Electrochemical Cells and Dye-Sensitized Solar Cells. Each laboratory experiment is carefully vetted for maximum laboratory exposure, while allowing students to explore the subjects being studied. The first laboratory experiment, a Redox Reaction, will demonstrate chemical energy as a portable source of energy. Through simple experimentation, students will observe the establishment of chemical energy through an Electrochemical/Redox Reaction. The second laboratory experiment, the construction of a Dye-Sensitized Solar Cell, will allow students to observe how nanoparticles can be used as a more efficient method of collecting solar energy, while also exploring the financial implications of using nanoparticles versus simple silicon-based solar cells.

Construction of Experimental and Chemical Products

As outlined in the previous Instructional Strategy, students will be exposed to two laboratory experiments, both which involve experimental and chemical products. Electrochemical (Redox) Reactions will involve Zinc Sulfate, Copper (II) Sulfate, Magnesium Sulfate, Tin (II) Chloride, and Zinc, Copper, Magnesium, and Tin Metal.
In the second laboratory experiment, students will have access to a Dye-Sensitized Solar Cell and will create their own DSSC during classroom instruction. From conception to implementation, students will be working with the DSSC Paste (TiO_2) and Iodine for the successful completion of their solar cell.

4 C's of 21st Century Skills

Communication, Collaboration, Critical Thinking, and Creativity

Each of the 4 C's of the 21st Century Skills are evident through the Curriculum Unit and students will be verbally focused on the skill as they are utilized throughout the Curriculum Unit. Students will be communicating using visual and verbal cues, both explaining their work and research, as well as presenting their progress and final products to the class in each of the lesson cycles. Collaboration is employed as students are working in teams on presentations and laboratory experiments, as well as independently researching and reporting to the whole-group. Collaboration, as specified in the Curriculum Unit, will be most important when it comes to specific problems posed to the students in individual learning cycles. Critical Thinking Skills will be most important in Global Awareness Scenarios that are presented to the students – they will have the opportunity to solve situations that are faced by citizens across the globe, as well as work to determine the best "system" of creating a sustainable city through provided resources. Surrounding each of the previous 3 skills is creativity – in order for students to be most successful in each activity, scenario, and experiment, students must use their creativity to solve problems, collaborate with their teammates to present factual information to the class, and work to solve the energy crisis that faces the country. Without the use of their creativity, each activity will lack the specific liveliness that is so often seen in IB Coursework.

Problem Solving, Group Work Skills, and Societal Case Studies
In the Curriculum Unit Instructional Cycles, there are three cycles that specifically focus on Problem Solving, Group Work Skills, and Societal Case Studies. In each of the three cycles, students will be presented with a classroom discussion, environmental case study, or societal implication and will be asked to dissect each situation to come to a solid conclusion. As an IB Level Student and Learner, students learn better from hands-on situations and experimental studies. Through learning the IB Program and focusing on how advanced well-trained IB Chemistry Teachers are in their classes, case studies have proven useful when wanting students to investigate the application of content knowledge to real-world scenarios. In this unit, students will be transitioning their knowledge base from the classroom into critical thinking and analytical scenarios, forcing them to make a decision along each step of the unit. As an example, in instructional cycle eight, the student's final assessment will be a case study into the use of solar cell on a plot of land. With details given, students will be asked to populate a plot of land with a type of alternative energy, but will have to scrutinize every aspect of building on the land – construction costs, environmental impacts of construction, and operating and employment costs to name a few. The case studies presented to the students will allow them to apply their content knowledge into a real-world application.

Skills Transferred to Students

During the Curriculum Unit, the students will use the following skills, translating from the International Baccalaureate Program to 21st Century Skills:

1. Using Theories to Explain Natural Phenomena
2. Scientific Community and Collaboration
3. Assessing the Ethics of Scientific Research
4. Public Understanding of Scientific Research
5. Transdisciplinary Studies

6. Collaboration and Significance of Science Explanations to the Public
7. Correlation and Cause and Understanding of Science
8. Environmental Problems (Risks and Benefits)
9. Trends and Discrepancies
10. Funding of Scientific Research

Instructional Cycle Planning

In the IB Program, Instructional Cycles are used in lieu of the traditional lesson plans. A lesson plan is "the instructor's road map of what students will need to learn and how it will be done effectively during the class time (typically one class period)[22]" while an instructional cycle is a long-term plan of education focused on a certain topic or subtopic and can range from one class period to multiple class periods, depending on the extent of the curriculum being taught. For example, Instructional Cycle 1 focuses on Renewable and Non-Renewable Resources as a poster project and the timeline for the cycle is two class periods, one for introduction and a work-session and a second for presentations. The following eight instructional cycles outline the standards being addressed in the time frame allotted. Further, the specific cycle is detailed, including a rigorous assessment of the Optional Topic and Curriculum Unit. The Curriculum Unit will be implemented approximately two months before the IB Exam is to be administered, giving plenty of time for instruction, review, and assessment for the unit.

Instructional Cycle	Cycle Plans
Cycle 1 2 Class Periods	Renewable & Non-Renewable Resources Visual Project (Standards C1 and C2)
Cycle 2 1 Class Period	Nuclear Fusion and Fission Classroom Discussion (Standards C3 and C7)
Cycle 3 1 Class Period	Human Impact on the Environment (Energy City Simulation) (Standard C5)
Cycle 4 2 Class Periods	Electrochemistry (Redox) Lab (Standard C6)
Cycle 5 2 Class Periods	Solar Energy Processes (Lecture) (Standards C4 and C8) DSSC Lecture and Nanoparticle Chemical Safety and Ethical Concerns (Standard C8)
Cycle 6 2 Class Periods	Dye-Sensitized Solar Cell Lab (Standard C8)

Instructional Cycle 1 – "Renewable & Non-Renewable Resources Visual Project"

Engage (5 Minute Preparation and 15 Minute Discussion)

To engage the students in Standards C1 and C2 and the Curriculum Unit, students will start out with the following questions (assigned the previous night as homework) to probe for their understanding of alternative energy and the usage of energy in society. Students should come into class with their answers and will have 5 minutes to prepare for a classroom discussion to probe for their understanding.

1. What is energy? What are the different flavors and forms of energy? What are the typical ways we produce it and transport it?
2. What is the history of energy use and the connections to history and the humanities?
3. What are the projected energy needs of the planet in the future? This discussion will necessitate studying the economic and energy patterns of not just the US but all countries. How can we project the scale of such need so that our students can understand the sheer scale of the energy we may require in the future? Is there an energy crisis on the horizon?
4. What technologies are available now and will be available in the near future that can scale to meet the future global energy requirements? This will involve exploring the science behind the technology, the present and future fuel resources needed to feed the technology, the real economic costs of scaling the technology, taking a hard look at the thermodynamic and efficiency limitations of the technology, and exploring the environmental impacts and sustainability of the tech. Is it possible and/or even feasible to provide all of our energy needs with just sustainable technologies alone?
5. What is the real impact of energy conservation?
6. What does our energy future look like? What societal changes are possible? What would an energy policy need to look like for the US now so we can be insured of adequate energy in the future? How will we define quality of life as we move towards a planet that might contain 9 billion people, all vying for the planet's energy resources?[23]

Instruction and Assessment

After completing the discussion of the engagement questions listed above, students will receive the instructions for the visual project. Using the following link (also listed as Appendix 2), the instructions for the visual project including the rubrics are listed for access. Introducing the project should take approximately 15 minutes, giving time to review the guidelines and the rubrics of grading. If students have questions about the instructions or rubrics, address those to clarify any misunderstandings. Before beginning the project worktime, break off the class into eight groups for the eight different types of energy. A modification to this would be for larger classes; if there are more than 24 students in the classroom, there can be ten groups created, breaking down the Fossil Fuels group into a Coal, Natural Gas, and Petroleum/Oil group. Each group should have 3-4 students per group and is absolutely modified depending on the size of the class. When the project has been explained, students will get into groups with their assigned members and will select a topic for research. This works best in one of two ways – students can either draw a topic from a jar/hat or the groups can be assigned by the teacher. Students will have the rest of the class period for research and for the creation of their visual project. For the project, allow two days for the instructional cycle to complete, as well as informing students they will most likely have work to do on their own time to prepare for the presentations occurring during the next class period. On the second day of the instructional cycle, students will have the class period to present their projects to the class, and presentations should be between 7-10 minutes. Depending on the number of groups in the class, a third day might be necessary for presentations, but that again is a modification made by the individual teacher. The rubrics for the presentations and the written articles are listed in Appendix 2 and linked above as the best version of printing. The formal assessment for Instructional Cycle One is the grades received from the presentation and the articles written.

Instructional Cycle Two – "Nuclear Fusion and Fission Classroom Discussion"

Engage (10 Minutes for Team Prep)

In the previous class session, the classroom was split in half: one half is PRO- Nuclear Fusion and Fission and the other half is ANTI- Nuclear Fusion and Fission. Their assignment was to read through the five articles and using other sources as well, prepare for a classroom discussion as to the pros and cons of Nuclear Fusion and Fission. Students should have research that supports their stance on whichever side they were assigned, factual evidence to support or argue against the use of Nuclear Fusion and Fission as a source of energy. Students will be given the first ten minutes in class to collaborate with their team in preparation for the discussion and to discuss the order that is presented to them (which should be presented to the students the day before the debate).

Instruction

To best suit the classroom discussion, another teacher or administrator might be useful to ask other questions and to determine the course of the discussion. Sides A and B can be interchanged for whichever team (Pro or Anti) will open and close the discussion. Each student must speak at least once during the discussion and once during the open forum, giving them the opportunity to present their findings during the research phase of the discussion.

The follow is a walk-through on how the setup will occur for the discussion:

1. Side A: Opening Statement (5 Minutes)
2. Side B: Opening Statement (5 Minutes)
3. Side A: Factual Evidence Supporting Their Position and Opposing the Other's Side Argument (10 Minutes)
4. Side B: Factual Evidence Supporting Their Position and Opposing the Other's Side Argument (10 Minutes)
5. Side A: Rebuttal (10 Minutes)
6. Side B: Rebuttal (10 Minutes)
7. Side A: Questions and Closing Statement (7 Minutes)
8. Side B: Questions and Closing Statement (7 Minutes)
9. Sides A and B: Open Forum and Discussion (15 Minutes)

Assessment

Summarization of Discussion and Talking Points
Refer to Appendix 3 for the Socratic Seminar Reflection. Students will complete the reflection as their assessment and to reflect on not only their position, but also the position of the opposing side.

Instructional Cycle Three – "Human Impact on the Environment"

Engage, Instruction, and Assessment (90 Minute Class Period)

In this instructional cycle, students will be working individually on the Energy City Simulation and answer the reflection questions listed in Appendix 4. Instructions and Questions listed in the appendix will guide the students in starting, practicing, and completing the simulation. Students should be guided through any technological glitches, but should complete the simulation themselves.

Instructional Cycle Four – Electrochemistry and Galvanic Cells Lab

Instructional Cycle Four focuses on the creation of a Galvanic Cell using the information learned from the Electrochemistry Topic (Topic 9 in the IB Curriculum and covered previously in the classroom instruction). Arbor Scientific[24] is the company that assembles and ships the kit and with the purchase of a kit, the laboratory instructions are included, from Pre-Laboratory, the completion of the experiment itself, and the conclusion questions. Using the document linked in the title, students will be working through the experiment under the guidance of the teacher. Safety should be managed through this instructional cycle, as the students are working with glass and chemicals. Proper safety protocols should be in place, per District Policies. The laboratory experiment should be set up the evening before or the morning of the laboratory experiment, with all materials being set out for the students to use.

Engage (20 Minutes for Preparation)

Students will be given 20 minutes to answer the Pre-Laboratory Questions (listed on Page 2 of the Galvanic Cells Document) and read through the Background Information presented to the students on Pages 2 – 5 of the Galvanic Cells Document. When students have completed the questions and background reading, discuss the answers listed on Page 2 of the document and ensure students have a good understanding of the laboratory experiment. Once that has been completed, students should read through the laboratory handout (see Pages 9 – 13 of the Galvanic Cells Document) and annotate when they have questions. Take time to answer the questions the students have, while ensuring safety protocols are in place for the experimentation.

Instruction (60 Minutes for Experimentation and Clean-Up)

Using Pages 9 – 13 of the Galvanic Cells Document, students will be performing the laboratory experiment and determining which cell produces the highest positive and lowest positive voltage, hence determining the “activity” of each galvanic cell.

Assessment (10 Minutes for Processing, Remaining Lab Work is Homework)

Using Pages 14 and 16 – 17 of the Galvanic Cell Handout, students will complete the Post-Lab Instructions and Assignment by answering each question individually and making curriculum connections between the content in the laboratory experiment and content learned through the course of the Curriculum Unit.

Instructional Cycle Five – Solar Energy Processes, DSSC Lecture, and Nanoparticle Chemical Safety and Ethical Concerns

Engage

Students will be given two scenarios and will be asked to find the solution to both scenarios individually. The first scenario: If the students are given the pieces of a solar cell, how do they fit together to create a solar cell? The second scenario: What are some of the major issues surrounding solar energy and nanoparticles?
When the students have been given time to complete both scenarios, discuss both as a class, just to see where their prior knowledge lies. This will also lead into the lecture portion of the instructional cycle.

Instruction

Lectures on Solar Cell Processes and Dye-Sensitized Solar Cells
(Power Points are linked to conserve space and for editing privileges)

Assessment

To assess student learning and to further push their knowledge, students will be asked the questions below to research and study on their own (as an assessment grade). Students should include a list of citations in which they received their sources: What is the Cost-Benefit-Analysis of a Solar Cell for a residential situation? If a homeowner were to look into a solar cell for their home, how long will it take to construct and how long will it take to earn back the money they put into the cell? Also, what are some of the chemical and ethical concerns in using nanoparticles in the solar cell, rather than the traditional SiO_2 solar cells? How might the use of nanoparticles not only increase efficiency in the solar cells, but also pose chemical and ethical concerns for their use?

Instructional Cycle Six – Dye-Sensitized Solar Cell Lab

Instructional Cycle Six focuses on the creation of a Dye-Sensitized Solar Cell ("Juice from Juice" Lab). Arbor Scientific[25] is the company that assembles and ships the kit and with the purchase of a kit, the laboratory instructions are included, from Pre-Laboratory, the completion of the experiment itself, and the conclusion questions. Using the document linked in the title, students will be working through the experiment under the guidance of the teacher. Safety should be managed through this instructional cycle, as the students are working with glass and chemicals. Proper safety protocols should be in place, per District Policies. The laboratory experiment should be set up the evening before or the morning of the laboratory experiment, with all materials being set out for the students to use.

Engage (20 Minutes for Preparation)

Students will be given 20 minutes to answer the Pre-Laboratory Questions (listed on Page 2 of the DSSC Document) and read through the Background Information presented to the students on Pages 5 – 11 of the DSSC Document. When students have completed the questions and background reading, discuss the answers from Page 3 of the document and ensure students have a good understanding of the laboratory experiment. Once that has been completed, students should read through the laboratory handout (see Pages 16-24 of the DSSC Document) and annotate when they have questions. Take time to answer the questions the students have, while ensuring safety protocols are in place for the experimentation.

Instruction (60 Minutes for Experimentation and Clean-Up)

Using Pages 16-24 of the DSSC Document, students will be performing the laboratory experiment and collecting data to measure efficiency of the solar cell.

Assessment (10 Minutes for Processing, Remaining Lab Work is Homework)

Using Pages 25-26 of the DSSC Handout, students will complete the Post-Lab Instructions and Assignment by answering Objectives 1, 3, and 4 on Page 25, as well as calculating the solar cell efficiency.

Appendix 1: Teaching Standards

For the Curriculum Unit, the following standards will be addressed, as outlined in the IB Chemistry Curriculum Guide (HL denotes Higher Level):

1. C.1 – Energy Sources
   Societies are completely dependent on energy sources. The quantity of energy is conserved in any conversion but the quality is degraded.
2. C.2 – Fossil Fuels
   The energy of fossil fuels originates from solar energy which has been stored by chemical processes over time. These abundant resources are non-renewable but provide large amounts of energy due to the nature of chemical bonds in hydrocarbons.
3. C.3 – Nuclear Fusion and Fission
   The fusion of hydrogen nuclei in the sun is the source of much of the energy needed for life on Earth. There are many technological challenged in replicating the process on Earth but it would offer a rich source of energy. Fission involves the splitting of a large unstable nucleus into smaller stable nuclei.
4. C.4 – Solar Energy
   Visible light can be absorbed by molecules that have conjugated structure with an extended system of alternating single and multiple bonds. Solar energy can be converted to chemical energy in photosynthesis.
5. C.5 – Environmental Impact (Global Warming)
   Gases in the atmosphere that are produced by human activities are changing the climate as they are upsetting the balance between radiation entering and leaving the atmosphere.
6. C.6 – Electrochemistry, Rechargeable Batteries and Fuel Cells (HL)
   Chemical energy from redox reactions can be used as a portable source of electrical energy.
7. C.7 – Nuclear Fusion and Nuclear Fission (HL)
   Large quantities of energy can be obtained from quantities of matter.
8. C.8 – Photovoltaic Cells and Dye-Sensitized Solar Cells (DSSC) (HL)
   When solar energy is converted to electrical energy the light must be absorbed and charges must be separated. In a photovoltaic cell both of these processes occur in the silicon semiconductor, whereas these processes occur in separate locations in a dye-sensitized solar cell (DSSC).

Appendix 2: Visual Project Instructions and Rubrics

Renewable & Non-Renewable Energy Visual Project

Purpose
Energy is extremely important in the fields of science and society today. The amount of energy that has to be used in industries, to power our electronics, heat our homes, fuel our cars, among other things is tremendous. In this project, you are going to explore one type of Renewable or Non-Renewable form of energy and present your findings to the class.

Task Definition
You are to create a visual presentation (Poster, Photo-Story, PowerPoint) which will be taught and displayed to inform your classmates about the various types of energy. Of the energy sources listed, select one that is particularly interesting to you and you know you can succeed on.

Energy Types for Presentation
Each group will be working on a different type of energy; no two groups will be doing the same.

Renewable Energy Sources	Non-Renewable Energy Sources
These sources of energy can be used over and over. • Solar • Wind • Geothermal • Biomass • Hydropower (River or Ocean)	These energy sources have a limited amount. They will eventually run out! • Fossil Fuels: Coal, Oil, and Natural Gas • Propane • Nuclear

What Should Be Included in the Presentation? Listed to the right is simply the minimum of what should be included. In order to receive the highest score possible, you should absolutely go above and beyond what is required of you.

Minimum Requirements for Project
1. Overview & History a. Summary of What the Energy Is. b. How was it Discovered? c. How has it Been Used in the Past?
2. Modern Use a. How is it Used Today? b. Laws Governing use of this Resource.
3. Advantages a. What Makes This Really Great!? b. What Makes It Better Than Fossil Fuels?
4. Disadvantages a. What are Some Problems? b. What Makes It Worse Than Fossil Fuels?
5. Necessary Equipment a. How Does It Work? b. Cost? (Is it Affordable? Will It Become Affordable?) c. Goals for the Future (How Will the Energy be Used in the Future?)
6. 10 Key Terms
a. Most Important Terminology (Descriptive Words) Needed to Understand Energy Type and Presentation.

Project Based Rubric	Incomplete 0-4 Points	Developing 5-6 Points	Accomplished 7-8 Points	Exemplary 9-10 Points
Use of Time ___/10 Points	Needs Frequent Reminders to Stay on Task, Work Not Completed on Time	Needs Few Reminders to Stay on Task, Completes Project on Time	Completes Work on Time Without Reminders	Competes work on time, stays on task and helps others when finished.
Teamwork or Group Participation ___/10 Points	Hinders or Disrupts Groups Ability to Complete Task Effectively, Needs Reminders to be Sensitive to Others	Works Toward Group Goals with Occasional Prompting; Sensitive to Others	Contributes to Project Without Prompting; Sensitive to Others	Actively Engaged in Groups Work; Encouraging Others in a Positive Manner
Visuals ___/10 Points	Missing or Do Not Contribute Information	Does Not Contribute Significantly to Presentation	Relates and Adds Value to Presentation; Not Polished.	Relevant, Increasing Interest of Audience; Polished
Neatness, Grammar & Spelling ___/10 Points	Handwriting Difficult to Read and Includes 3 or More Spelling or Grammar Errors.	Includes More than 3 Spelling and Grammar Mistakes or Handwriting not Neat.	Includes up to 3 Spelling or Grammar Mistakes, Typed or Neatly Written	Typed or Neatly Written, No Spelling or grammar errors.
Completeness ___/10 Points	Missing More Than 4 Components Requested by Teacher.	Missing 3-4 of the Components Requested by Teacher	Missing 1-2 of the Components Requested by Teacher	Includes All of the Information or Components Requested by the Teacher

Final Product ___/10 Points	Missing Many Requirements, Lacks Polish, Thrown Together Without Serious Effort	Missing a Few Requirements, but Looks Good! Some Effort Made.	Includes All Requirements but Finished Product Lacks Polish, Thrown Together	Includes All Requirements, Polished Finished Product, Work to be Proud of!
Speaking ___/10 Points	Hesitates, Low Voice, Poor Eye Contact, Many "Fillers"	Some Hesitation, Few Fillers, Some Eye Contact but Mostly Reads	Clear Voice, Good Pace and Pronunciation, Checks Notes	Clear Voice, Good Projection and Pace, Well-Rehearsed, Little Need for Notes, Good Eye Contact.

Renewable & Non-Renewable Energy Article

In addition to your poster, you must write a 1-2-page article about the alternative energy technology that you are working on. This article should be typed and single-spaced. You must reference at least 2 magazine or newspaper articles and 2 websites for the article you write, which much be cited in MLA or APA Citation.

In Your Article, You Must Include:

1. Summary of How It Works (Restating the Information in Your Poster)
2. Benefits and Limitations of the Technology (Pros and Cons)
3. A List of Articles and Websites You Gathered Information From (Citations)

Present Your Article in the Format of a Newspaper or Some Other Publication with Pictures.

Project Based Rubric	Exemplary 9-10 Points	Accomplished 8-7 Points	Developing 4-6 Points	Incomplete 0-3 Points
Completion ___/10 Points	Paper Contains All Sections Assigned, Including Graphs, Tables, and Relevant Visual Aids	Paper Contains All Sections, but is Missing Graphs or Visual Aids	Paper Contains Most of the Sections or Paragraphs Assigned	Paper Unfinished, Lacks Major Sections or Paragraphs
Content ___/10 Points	Accurate, Logical, Includes Author’s own Thoughts, Considers Implications, Demonstrates Thorough Understanding of Topic	Accurate and Logical Information, Including Author's Thoughts with Research; Demonstrates Satisfactory Understanding of Topic	Accurate and Logical, but Does Not Incorporate Author's own Thoughts and Ideas; Demonstrates Minimum Understanding of Topic	Content is Unrelated to Topic, Significant Misconceptions Apparent, Missing Key Ideas

Organized _____/5 Points	Logical Sequence, Easy to Follow, Strong Introduction and Conclusion with Clear Transitions	Logical Sequence of Ideas, Readers can Follow Author's Thought Process	Attempts to Organize Ideas, but Reader has Difficulty Following	Unorganized and Difficult to Read
Neatness, Grammar & Spelling ___/5 Points	Typed or Neatly Written, no Spelling or Grammar Errors	Includes up to 3 Spelling or Grammar Mistakes, Typed or Neatly Written	Includes More than 3 Spelling and Grammar Mistakes or Handwriting not Neat	Handwriting Difficult to Read and Includes 3 or More Spelling or Grammar Errors

Appendix 3: Socratic Seminar Reflection

Optional Topic C: Energy
Socratic Seminar Reflection

Opening Questions

1. Summary of Your Key Ideas

2. Reaction: Identify What Someone Said and Write Down His/Her Comment(s). React to His/Her Statement(s).

3. Explain how the Seminar Influenced Your Thinking About the Topic or the Texts.

Self-Assessment

Prepared for Seminar by Reading Text, Highlighting and Preparing Questions.	3	2	1
Taking a Position on a Question	3	2	1
Using Evidence to Support a Position or Presenting Factual Information	3	2	1
Drawing Another Person into the Discussion	3	2	1
Asking a Clarifying Question or Moving the Discussion Along	3	2	1

Appendix 4: Energy City Simulation

Energy City Worksheet (Hyperlinked for Best Printing Practices)
Register as a student and play "Energy City" at the following website:
Energy City Simulation

Simulation Directions

1. Read through the Introductory Paragraph before clicking "Play Now."
2. When you get to the simulation, click "Learn More" to practice using the features of the simulation. As the simulation walks you through the individual components, try to think of a game plan for how you would create and run an energy efficient city, as this will help you prepare for you running your final simulation.
3. When you have finished running through the instructions, begin playing with Beacon Plains in Expert Mode (20-Year game) to practice with.
4. When you have practiced for a few rounds, you will be running your final simulation. For your final simulation, use results from the most challenging level and mode you experienced.

Section A - Simulation

1. How are my choices of energy sources impacting my city's local air quality, global environment, and budget?
2. What is the cheapest energy source?
3. What is the most expensive energy source?
4. What is the most powerful energy source?
5. What is the least powerful energy source?
6. What is the best energy source for the environment? Why?
7. What is the worst energy source for the environment? Why?
8. Why is it important to take stakeholders into consideration?

Section B – Connections to Society and Globalization of Scientific Knowledge

1. As a scientifically literate citizen, write a recommendation to your local government on how they should be spending your tax dollars on future power generation for your town. Be sure to consider the following perspectives:
    - Social and Governmental Perspectives
    - Economic Risks and Benefits (Cost-Benefit-Analysis)
    - Environmental Impacts and Benefits

   Your recommendation should include factual evidence from the simulation and should be written as to persuade the local government on the best source of renewable energy for your town. Be creative!

List of Materials for Classroom Use

Instructional Cycle One

Chromebooks and Scratch Paper for Thought Processing

Instructional Cycle Three

Chromebooks

Instructional Cycle Four

When ordering the kit from Arbor Scientific, each kit comes with 5 Student Stations, so order according to class sizes. Having 36 Juniors and 21 Seniors, I ordered 20 kits and received a discount for the bulk order.

1. 20 Filter Papers (Whatman, Grade 1)
2. 15 Well-Plates (12 Depressions)
3. Zinc Foil
4. Copper Foil
5. Tin Foil
6. Magnesium Ribbon
7. 25 grams Copper (II) Sulfate
8. 25 grams Magnesium Sulfate
9. 25 grams Zinc Sulfate
10. 25 grams Tin (II) Sulfate
11. 1 Graduated Cylinder, 25-mL
12. 4 Squirt Bottles, 2 ounces
13. 5 Digital Multimeters (Included in the Dye-Sensitized Solar Cell Kits)
14. 10 Alligator Clips (Included in the Dye-Sensitized Solar Cell Kits)
15. 1-L Distilled Water
16. 1 Bag of Spinach
17. 1 Container of Salt, NaCl
18. Scale accurate to 0.01 grams

Instructional Cycle Six

When ordering the kit from Arbor Scientific, each kit comes with 5 Student Stations, so order according to class sizes. Having 36 Juniors and 21 Seniors, I ordered 20 kits and received a discount for the bulk order.

1. 5 Digital Multimeters
2. 10 Alligator Clips
3. 15-mL Iodide/Triiodide Electrolyte Solution
4. 25-mL Titanium Dioxide Paste
5. 30 FTO Glass Electrodes (2.0 x 2.5 x 0.3 cm)
6. 30 Pipettes, 2-mL
7. 30 Binder Clips, Small
8. 15 Golf Pencils
9. 15 Tweezers
10. 15 Zip-Lock Backs
11. 1 Roll Scotch Tape
12. 5, 2-ounce Squirt Bottles
13. 10 Red LED's
14. 1 Solar Cell, 0.5 V, 400 mA
15. 1-L Distilled Water
16. 15 Blackberries
17. 15 Blueberries (for further investigations)
18. 15 Raspberries (for further investigations)
19. 15 Strawberries (for further investigations)
20. Hot Plate

Teacher and Student Resources

Alley, Richard B. Earth, The Operator's Manual. New York: W.H. Norton & Company, Inc., 2011.

This book is excellent for a teacher who wishes to increase their personal content knowledge before tackling the subject of energy with their students.

American Council for an Energy-Efficient Economy. Accessed August 21, 2016. http://aceee.org/

This website gives some good policy on the fight for an energy-efficient economy and what the government is currently facing when it comes to energy policy. As well, it gives articles on energy efficiency and the status of energy movements.

Arbor Scientific. “Dye Sensitized Solar Cell Kit.” Accessed September 15, 2016. http://www.arborsci.com/dye-sensitized-solar-cell-kit-16

This website is great because teachers can buy lab kits for their students and are given the lesson plans for using the kits.

Arbor Scientific. “Electrochemistry and Galvanic Cells Kit.” Accessed September 15, 2016. http://www.arborsci.com/dye-sensitized-electrochemistry-kit-16

This website is great because teachers can buy lab kits for their students and are given the lesson plans for using the kits.

“Energy City Simulation.” JASON Science: Education through Exploration. 2011. Accessed November 1, 2016. http://gated.jason.org/digital_library/cfy/8239.aspx

This simulation will help students understand the importance of balancing air quality, finances, and stockholders while trying to create an eco-friendly city.

McCaffrey, Paul. U.S. National Debate Topic 2008-2009: Alternative Energy. New York: H.W. Wilson Company, 2008.

This book features essays on both sides of the alternative energy debate. It includes arguments from leading researchers in the climate change fields and is a good analysis for students and teachers trying to come to a general consensus about climate change and the next steps for our country.

Rinkesh, “What are Non-Renewable Sources of Energy,” *Conserve Energy Future Blog***.** Accessed October 15, 2016. http://www.conserve-energy-future.com/NonRenewableEnergySources.php

This blog gives students and teachers a perspective on renewable and non-renewable energy sources. Further exploration of the blog breaks down the types of renewable energy (solar, wind, hydroelectric) and gives a perspective that is easy to understand on the usage and the pros and cons of each type.

Penfield High School. "Nuclear Energy Socratic Seminar Articles" WikiSpaces. May 19, 2015. Accessed September 22, 2016. https://penfieldhighlibrary.wikispaces.com/Nuclear+Energy+Socratic+Seminar+Articles
This teacher's website had some great resources for Socratic Seminars and articles to be used during the seminars. The articles give an unbiased opinion on Nuclear Energy and the reflection sheet is open-ended for the students to process their thoughts on the discussion.

"Questions and Answers on the Paris Agreement." European Commission: Climate Action. December 2015. Accessed October 22, 2016. http://ec.europa.eu/clima/policies/international/negotiations/paris/docs/qa_paris_agreement_en.pdf
When President Obama signed the Paris Agreement, the United States took a step towards monitoring our footprint on the climate. This website gives a lot of answers towards the Paris Agreement and what it actually means for America and its scientists.

Woodard, Colin. "America's First All-Renewable Energy City," Politico Magazine, last modified November 17, 2016, accessed November 18, 2016, http://www.politico.com/magazine/story/2016/11/burlington-what-works-green-energy-214463
This article will help students on how a city can transform into a completely alternative energy city, removing its dependency on energy types that most commonly destroy the environment.

Bibliography

[1] Somanader, Tanya. "President Obama: The United States Formally Enters the Paris Agreement." The White House. September 3, 2016. Accessed October 8, 2016. https://www.whitehouse.gov/blog/2016/09/03/president-obama-united-states-formally-enters-paris-agreement
In September 2016, President Obama signed the Paris Agreement, which joined the United States with other nations in the fight against climate change. The Paris Agreement outlines how these countries will reduce emissions and increase the use of renewable resources as energy sources in their respective countries.

[2] Pillion, Dennis. "Alabama Pipeline Leak: What we Know so Far About the Spill, Gas Shortages, and More." AL.com. September 18, 2016. Accessed September 19, 2016. http://www.al.com/news/birmingham/index.ssf/2016/09/how_alabama_pipeline_leak_led.html
In September 2016, after the Paris Agreement was signed by President Obama, Alabama saw a major gas leakage which halted the flow of gas from AL to other states along the east coast. The spill caused environmental impacts in the direct region and economic impacts in the states that receive fuel from the specific pipeline. The article outlines what is currently known about the fuel spill.

[3] Pillion, Dennis. "Alabama Pipeline Leak: What we Know so Far About the Spill, Gas Shortages, and More." AL.com. September 18, 2016. Accessed September 19, 2016. http://www.al.com/news/birmingham/index.ssf/2016/09/how_alabama_pipeline_leak_led.html
In September 2016, after the Paris Agreement was signed by President Obama, Alabama saw a major gas leakage which halted the flow of gas from AL to other states along the east coast. The spill caused environmental impacts in the direct region and economic impacts in the states that receive fuel from the specific pipeline. The article outlines what is currently known about the fuel spill.

[4] "Class of 2015 Profile." Myers Park High School. Accessed October 21, 2016. http://schools.cms.k12.nc.us/myersparkHS/Documents/School%20Profile%20Class%20of%202015.pdf
Demographics about the Myers Park High School Graduating Class of 2015, for statistical purposes of the Curriculum Unit.

[5] "A Brief History of IB." International Baccalaureate. Accessed August 1, 2016. https://ib.ednet.ns.ca/brief-history-ib

For educators who are unsure about the International Baccalaureate (IB) Program, how it was formed, and how it is outlined in schools, the article describes the program and gives access to more information about the IB Program.

[6] "The Presidential Timeline." The US National Archives and Records Administration. Accessed July 15, 2016. http://www.presidentialtimeline.org/#/timeline/37
This website provides information about individual Presidents (up until George W. Bush) and major accomplishments/current events of their time as President. Extremely useful if trying to establish the timeline of Presidents for major world events.

[7] "Oil Embargo, 1973-1974." Office of the Historian. Accessed July 15, 2016. https://history.state.gov/milestones/1969-1976/oil-embargo
The Oil Embargo of 1973 both banned petroleum exports to targeted nations and introduced cuts in oil production. This website provides a detailed explanation of the embargo and the effects on the history of the United States, which is often seen as the pivotal point in the energy sector. The embargo was a deciding point in gearing up for renewable energy and lessening our dependence on foreign oil.

[8] Fernald, Fluor. "History of the U.S. Department of Energy." Fernald Closure Project. Accessed September 15, 2016. http://www.lm.doe.gov/land/sites/oh/fernald_orig/aboutfernald/dhist.htm
This website provides a short history of the Department of Energy and how the role of the department has changed through its formation.

[9] "A Brief History of the Department of Energy." Energy.Gov: Office of Management. Accessed September 28, 2016. http://energy.gov/management/office-management/operational-management/history/brief-history-department-energy
This website provides a short history of the Department of Energy and how the role of the department has changed through its formation.

[10] "Fossil Fuels Have Made up at Least 80% of U.S. Fuel Mix Since 1900." Today in Energy. July 2, 2015. Accessed July 10, 2016. http://www.eia.gov/todayinenergy/detail.php?id=21912
This website is useful in trying to see (both written and graphically) how the United States has accessed energy through the years 1776-2014. It shows how coal and petroleum have declined since the creation of renewable energy and how the reliance on fossil fuels is still relatively high for the advancement of society and science currently.

[11] "Paris Agreement." European Commission: Climate Action. December 2015. Accessed October 22, 2016. http://ec.europa.eu/clima/policies/international/negotiations/paris/index_en.htm
Details of the Paris Agreement and what each country is responsible for after signing the agreement, as well as the deadline for each country, including the United States.

[12] "Monthly Energy Review." U.S. Energy Information Administration. November 22, 2016. Accessed November 22, 2016. http://www.eia.gov/totalenergy/data/monthly/index.php

Each month, the US Energy Information Administration published statistics about the energy usage in the United States. Information published is separated by type of energy, sector in which the energy is used, and cost of energy among others. Useful site that provides current information of the energy usage in the United States.

[13] "Fossil Fuels Have Made up at Least 80% of U.S. Fuel Mix Since 1900." Today in Energy. July 2, 2015. Accessed July 10, 2016. http://www.eia.gov/todayinenergy/detail.php?id=21912

This website is useful in trying to see (both written and graphically) how the United States has accessed energy through the years 1776-2014. It shows how coal and petroleum have declined since the creation of renewable energy and how the reliance on fossil fuels is still relatively high for the advancement of society and science currently.

[14] "Ozone Hole Watch." National Aeronautics and Space Administration. November 20, 2016. Accessed November 21, 2016. http://ozonewatch.gsfc.nasa.gov/

This is a website published through NASA and is updated daily about the ozone layer around the globe. It also gives quick facts as to what is ozone, what is the ozone layer, and why the hole in the ozone layer is critical to the health of wordly citizens.

[15] "What is the United States' Share of World Energy Consumption." U.S. Energy Information Administration. November 22, 2016. Accessed November 22, 2016. https://www.eia.gov/tools/faqs/faq.cfm?id=87&t=1

This website, published by the US Energy Information Administration, gives quick facts about the usage of energy by the United States. Further exploration shows more information about energy usage in the US and also in other countries.

[16] "Monthly Energy Review." U.S. Energy Information Administration. November 22, 2016. Accessed November 22, 2016. https://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf

Each month, the US Energy Information Administration published statistics about the energy usage in the United States. Information published is separated by type of energy, sector in which the energy is used, and cost of energy among others. Useful site that provides current information of the energy usage in the United States.

[17] Shiva. "How Solar Cells Work – Components & Operation of Solar Cells." May 13, 2013. Accessed August 1, 2016. http://solarlove.org/how-solar-cells-work-components-operation-of-solar-cells/

For anyone who is trying to determine how solar cells works, this is a great website that offers basic information about the processes of the solar cell, the structure of the cell, and how one obtains energy through the solar cell.

[18] "Short-Term Energy Outlook." U.S. Energy Information Administration. November 8, 2016. Accessed November 12, 2016. http://www.eia.gov/forecasts/steo/report/renew_co2.cfm?src=Environment-b1

Each month, the US Energy Information Administration published statistics about the energy usage in the United States. Information published is separated by type of energy, sector in which the energy is used, and cost of energy among others. Useful site that provides current information of the energy usage in the United States.

[19] "Photovoltaic Research." National Renewable Energy Laboratory. Accessed August 18, 2016. http://www.nrel.gov/ncpv/images/efficiency_chart.jpg

For anyone who is trying to determine how photovoltaic cells works, this is a great website that offers basic information about the processes of the cell, the structure of the cell, and how one obtains energy through a photovoltaic cell.

[20] Woodard, Colin. "America's First All-Renewable Energy City," Politico Magazine, last modified November 17, 2016, accessed November 18, 2016, http://www.politico.com/magazine/story/2016/11/burlington-what-works-green-energy-214463

The article, published by Politico Magazine, highlighted Burlington, Vermont as the first US City to run successfully on 100% renewable energy, to help start a movement in smaller cities running off renewable energy. As climate change becomes more of an important issue, Burlington, VT took a stand to show how cities can effectively plan and execute reliable and renewable energy sources.

[21] Pantsios, Anastasia. "Burlington, Vermont Becomes First U.S. City to Run on 100% Renewable Electricity." EcoWatch. February 10, 2015. Accessed September 22, 2016. http://www.ecowatch.com/burlington-vermont-becomes-first-u-s-city-to-run-on-100-renewable-elec-1882012101.html

The article, published by EcoWatch, highlighted Burlington, Vermont as the first US City to run successfully on 100% renewable energy, to help start a movement in smaller cities running off renewable energy. As climate change becomes more of an important issue, Burlington, VT took a stand to show how cities can effectively plan and execute reliable and renewable energy sources.

[22] Fink, D.L. "Strategies for Effective Lesson Planning." University of Michigan Center for Research on Learning and Teaching. 2005. Accessed September 21, 2016. http://www.crlt.umich.edu/gsis/p2_5

To better define the difference between a lesson plan and an instructional cycle, this site was accessed to provide a definition. Instructional cycles are used in the curriculum unit rather than traditional lesson plans due to the nature of the classes taught (IB Program).

[23] Striplin, Durwin. "The Global Energy Challenge." Charlotte Teachers Institute. Accessed September 28, 2016. http://charlotteteachers.org/seminars/2014-seminars/the-global-energy-challenge/
Durwin Striplin presented a CTI Seminar in 2014 about the advancement of society and the advancement of energy as well. Listed on the CTI Website were six starter questions about the energy profile of the United States and the development of the energy sector, which are used to start off the curriculum unit.

[24] Arbor Scientific. Accessed August 3, 2016. http://www.arborsci.com/
This website is great because teachers can buy lab kits for their students and are given the lesson plans for using the kits.

[25] Arbor Scientific. Accessed August 3, 2016. http://www.arborsci.com/
This website is great because teachers can buy lab kits for their students and are given the lesson plans for using the kits.