Development of an Energy Plan for Franklinville using a Single Energy Source

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Overview

This minds-on activity guides students in analyzing specific examples of energy sources (e.g. coal, solar, geothermal, and hydropower) and develop their understanding of renewable and non-renewable energy sources. The introductory analysis and discussion section use a scenario to introduce students to key concepts and discuss the three artifacts that students need to produce at the end of the curriculum unit: (1) an energy sources spreadsheet; (2) a small group argument essay; (3) an individual argument essay. The second section includes students working in small groups to interpret the given data; generate a tentative argument on which source of energy that can provide more electricity for Franklinville; and, participate in a peer-evaluation activity to evaluate the quality of each group argument. In the third section, each student creates a final written argument to persuade their peers and teacher that their claim is valid and acceptable.

I estimate that it will take roughly 5 days in a 50-minute class or 2 days in a 90-minute class to complete these three sections with an average class of high school students or with a relatively advanced class of high school students.

Rationale

The universe is made up of matter and energy. Matter is made up tiny particles called atoms, and atoms are composed of even smaller components. Energy is the ability to do work; energy is the mover of matter. Energy produces light, heat, motion, sound, growth, and chemical reactions (The NEED Project 2013, p. 8). All energy can be categorized into two major forms: kinetic and potential energy. Kinetic energy is the energy of motion; the motion of waves, electrons, atoms, molecules, substances, and objects (ibid, p. 9). On the

other hand, potential energy is stored energy and the energy of position such as gravitational energy (ibid, p. 8). The total amount of energy in the universe is constant. It can never be destroyed or made, which is known as the Law of Conservation of Energy. Nonetheless, the state of energy can be changed from one form into another. “A car engine burns gasoline, converting the chemical energy in the gasoline into motion energy that makes the car move” is an example of the state of energy changing from chemical to mechanical energy (ibid, p. 9). Energy is measured in joules. The rate of work done during a certain time is called power. Power is measured in watts. A watt is the unit of the rate of energy conversion or transfer with respect to time. These units allow us to determine, for examples, the energy contained in a gallon of gasoline, diesel, or other energy sources.

Human beings have always used energy to do work for them. More importantly, people have learned how to change energy from one form to another so that they can do work more easily and live more comfortably. Early humans discovered fire and used it to provide light, heat their homes, and cook their food (ibid, p. 10). Later, humans learned to use the wind to navigate their boats from place to place. Now, people have electricity to power their homes, watch television, and surf the internet. The major sources of energy we use today can be classified into two categories: nonrenewable and renewable. Nonrenewable energy is energy that cannot be replenished in a short period of time. They include coal, petroleum, natural gas, and propane (ibid). These energy sources were formed millions of year ago from the remains of dead plants and animals that sank to the bottom of the ocean and covered with mud and water (ibid). Heat and pressure turned dead plants and animals into fossil fuels such as coal, oil, and natural gas (ibid). Eventually, we will run out of non-renewable energy supplies like coal, oil and natural gas (ibid). Long before that happens, the pollution caused by using these energy sources will become a serious problem (ibid). According to the U.S. Energy Consumption Report 2013, 90% of our electricity comes from non-renewable sources. So, it is imperative we find a way to relinquish our dependency on non-renewable energy. Yet, according to the U.S. Energy Consumption Report 2013, 10% of our energy comes from renewable energy sources. These energy sources include biomass, geothermal, hydropower, solar, and wind. These sources of energy are known as renewable energy because we will not run out of them; they are always re-made by nature. Nonetheless, electricity is neither a renewable or non-renewable energy. Electricity is a secondary source of energy, which means electricity is made by using another source of energy such as coal, uranium, solar, hydropower, and biomass. In the United States, coal is the number one fuel for generating electricity (ibid). In the curriculum unit, student groups are challenged to develop an electrical plan using one of the listed energy sources for Franklinville.

Science argumentative writing will be used as the instructional tool for students to conceptually understand energy; renewable and nonrenewable energy sources; and, sustainability is the fuel of the future. One of the Common Core State Writing Standards calls for students to learn to “write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence” (p. 66). Another aim of the Common Core State Standards is “for all students to become proficient in science by the time they finish high school” (p. 60). Lastly, argumentation is a critical thinking process used by scientists to support their data gathered through an investigation (Sampson and Schleigh 2013, p. xi). It is one form of language scientists used to judge the quality or

reliability of evidence presented by their peers. For all the above and more, I will be using science argumentation as my instructional tool for students to learn the content in the curriculum unit.

Argumentative writing is not persuasive writing. Argumentative and persuasive writings both aim to present a specific point of view, but they are different both in how they get their point across and why. The author of an argumentative essay will usually try to make his or her point through reason. This means identifying the opposing viewpoints and then using facts, statistics or other evidence to discredit them so that the reader ultimately concludes that the writer's position is correct. The persuasive essay on the other hand, more often uses passion and emotion in an attempt to sway the reader's loyalties. The purposes of persuasive writing include seeing goods and services, promoting a particular cause, view or interest by any means (i.e. propaganda). They make claims but aren't always substantiated, i.e. they bear no burden of proof. Opposing views may be acknowledged but aren't usually analyzed. As a result this sort of essay is often perceived to be essentially one-sided and is written primarily on personal convictions.

Second, argumentative writing in science is different from other subjects such as history, English, and politics. In a science argumentative essay, an argument consists of a claim, evidence, and a justification of the evidence (Sampson, Enderle, Grooms 2013, p. 30). The claim is a conjecture, conclusion, explanation, or a descriptive statement that answers a research question (ibid, p. 31). The evidence section of an argumentative writing in science is obtained by analyzing measurements, observations, or data and make then provide an interpretation of the analysis (ibid). The last part - the justification of the evidence - is a statement or two that explains the importance and the relevance of the evidence by linking it to a specific principle, concept, or underlying assumption (ibid, p. 32). This form of instructional practice will teach students how to argue from evidence and evaluate information in the context of science. My hope is to use science argumentation in such a format to teach my students about energy sources in my physical science class.

Objectives

The unit is intended for high school students, grades 9—12. In general, in the School District of Philadelphia (SDP), students are required to take a minimum of three years of science to fulfill the graduation requirements. Freshmen are taught Physical Science; sophomores are taught Biology; and, juniors are taught Chemistry. The topics renewable and nonrenewable energy and sustainability fall on the environment science section of the physical science course, which are taught during the 4th marking period. My aim is to teach this unit to 9th graders in a physical science during the 4th marking period. However, this unit can be taught during the 1st marking period when teaching students about energy.

Learning goals are related to the National Standards in accordance to the *Next Generation Science Standards* and *A Framework for K-12 Science Education*:

- Students will gain understanding of two Disciplinary Core Ideas:

- MS-PS3-5 Energy: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
- MS-PS1-3 Matter and its Interactions: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

The objectives of the unit will be:

- Students will be able to identify types of energy and analyze conversions between types of energy
- Students will be able to explain how energy is conserved
- Students will be able to apply the knowledge of conservation of energy to explain common systems (e.g., refrigeration, rocket propulsion, heat pump)
- Students will be able to differentiate between renewable, nonrenewable and inexhaustible energy sources
- Students will be able to give examples of renewable energy resources and nonrenewable resources and explain the environmental and economic advantages and disadvantages of use.

Students will engage in several scientific practices:

- developing and using models
- using mathematics
- analyzing and interpreting data
- constructing explanations
- arguing from evidence

Strategies

The strategies that I hope to incorporate in my unit are as follows:

- Scaffolding—design questions to assist learners in achieving learning goals.
- Cooperative learning—having students work together in small groups for the achievement of learning goals.
- Active learning—instructional strategies that allow students to move around the classroom, stimulate critical thinking and greater awareness of content and learning.
- Inquiry-based learning—instructional strategies that allow students to think methodologically and investigate strategies that help students yield the desired learning outcomes.

Classroom Activities

I'm going to use the instructional model Generate an Argument (Sampson and Grooms 2010) to explain how to incorporate the curriculum unit in 4 days in a 50-minute class. This mode of instructional strategy requires students to develop a claim that answers a research problem based on a supplied data set (Sampson and Schleigh 2013). Also, the curriculum unit is an

adoption of the National Energy Education Development's curriculum unit titled *Mission Impossible* (2013). However, the differences between my curriculum unit and theirs are students create an electricity capacity for the town using each energy source independently and decide which energy source is the best option instead of "mixing the different energy sources to produce the required amount of electricity, while staying within the budget and maintaining the environmental quality of the country" (p. 10). My aim for pursuing this route is for students to understand if given the same amount of generating capacity of electricity each energy source will have different amount of economic cost and environment cost on the town. As a result, students will be able to evaluate the advantages and disadvantages of the energy sources used to generate electricity. However, like the *Mission Impossible* curriculum, there are a limited number of variables and it is not intended to reflect the realities of a town's electricity capacity.

Day 1: The Problem

The first part of the activity can be completed three different ways: The first option is students use computers to complete the *Blank Energy Sources Spreadsheet* in excel. The second option is students use calculators to complete the *Blank Energy Sources Spreadsheet*. The third option is to give the students the *Completed Energy Sources Plan Spreadsheet*. I will be describing the procedures for the second option since I don't have computers in my classroom.

Teacher initiates the activity by identifying the problem to investigate. The goal of the teacher at this stage is to capture the students' interest and provide them with a reason to engage in this activity. Provide each student with a copy of the *Scenario* and explain the activity to the class. Make sure that students understand that in this activity they are exploring the trade-offs of each energy source and which energy source can provide electricity without substantial economic and environmental impacts on Franklinville. The teacher needs to stress to the students that the students' goal is to explain how they know what they know and their conclusion is valid (Sampson and Grooms 2010, p. 33). After introducing the assignment to the student, the teacher should divide the class into small groups (preferably three students per group), and explain that they will be working in a group to complete one of the major parts of the unit. The teacher should provide each group with a copy of the *Master Energy Sources Spreadsheet with Formulas* and *Completed Energy Sources Plan Spreadsheet*; explain the data set to the student; answer any questions about the given data set; and, explain to the students that they are going to use the formulas on the *Master Energy Sources Spreadsheet with Formulas* to complete the *Completed Energy Sources Plans Spreadsheet*. I recommend that the teacher completes one column as an example for students. The second part of day 1, the teacher should provide each group with a copy of the *Energy Sources in Franklinville*.

Next, the teacher should select a student to read each section of the worksheet. The teacher should explain and clarify the expectations, answer questions, or provide additional information as needed for the activity. The last stage of day 1, once all students have a general understanding of the worksheet, the teacher should provide each group with the *Argument Instructional Model Worksheet* and explain what they need to accomplish while they're in small group.

Day 2: Generate a Tentative Argument

During day 2 of the unit, students need to start using the raw data that is supplied to them in the unit to determine which energy source will benefit Franklinville economically, while maintaining the quality of the country's environment. Student should return to their group. Each group should be using the *Argument Instructional Model Worksheet* to assess each document and determine which energy source provides the most valid or acceptable claim. The intention of this stage is to provide students with an opportunity to examine their spreadsheet and facts about energy sources in Franklinville. Students are given the opportunity to make sense of what they are seeing or doing. At this time, teacher should make sure that students work together to determine how to analyze the data and how best to interpret the trends, difference, or relationships that they uncover. The teacher should be walking around the classroom aiding and questioning each group if they have been analyzing and interpreting the data; if their argument is relevant, sufficient, and convincing enough to support their claim. The teacher should guide each group in constructing their claim and making their argument. Once the groups have examined and analyzed the data, the teacher should instruct each group to create a tentative argument that consists of (1) their chosen energy source (2) their evidence (the data that has been analyzed and interpreted) and, (3) a statement that explains why the evidence they decided to use is important or relevant on a medium that can be easily viewed by their classmates. A large whiteboard can be used by each group to write their argument and display it in the classroom.

Day 3: The Argumentation Session

The third stage in the curriculum unit is the argumentation session. In this stage, which is scheduled during the third day, students are given opportunity to share, evaluate, and revise their argument or process of their investigation with their classmate. The teacher should instruct that everyone returns to their designated group. The teacher should instruct that each group needs to choose one member of the group to stay at their workstation. This person will serve as the expert of the group and share the group's ideas to the other group members. The other two members of the group will go to the other groups one at a time in order to listen to and critique the arguments developed by your classmates. Each student must also decide if the group's claim is valid and how well they are able to support their argument using the given data by answering the following questions:

- How did you analyze or interpret your data? Why did you decide to do it that way?
- How do you know that your analysis of the data is free from errors?
- Why does your evidence support your claim?
- Why did you decide to use that evidence? Why is your evidence important?
- How does your rationale fit with accepted scientific ideas?
- What are some of the other claims your group discussed before agreeing on your claim, and why did you reject them?

After answering all the questions, students should return the completed questionnaires to the teacher. This would conclude the third day of the unit.

Day 4: A Reflective Discussion

During the fourth day of the curriculum unit, the original groups of students reconvene and discuss what they learned from the interaction with individuals from the other groups. The teacher should return the completed questionnaires to each group. Next, the teacher should

encourage each member of each group to think and discuss why some claims that they've read and seen are more valid or acceptable to the research question. Based on the discussion within the group and the completed questionnaires form other students, each group should then modify their tentative argument as needed on a whiteboard. After each group has modified their argument, the teacher should lead a whole-class discussion on what they learned about their investigation and other related questions concerning their development of an energy plan for Franklinville.

Days 5 and 6: The Production of a Final Written Argument

In the final stage of the curriculum, which can be completed in one or two days, each student is required to make sense of his or her experience by producing a final argument in writing using the *Generating an Argument Writing Prompt Worksheet*. Provide each student a copy of *Generating an Argument Writing Prompt Worksheet* and have the student write his or her argument under the prompt. Or, if students have access to computers, the teacher can project the prompt on a whiteboard for all students to see and have students write their argument on a word processing application. The *Student Response Scoring Rubric* can be used to score students' arguments; this rubric includes criteria that focus on the components of a quality argument in science (e.g., evidences, organization, and justification).

Scenario

Instructions: You are about to work on an activity that is designed to assess your skills of critical thinking, reasoning, problem solving and written communication. In addition to these important "scientific" skills, your knowledge about different energy sources will be evaluated. You will prepare a written response to a realistic situation. In this activity you will find a series of documents that include a wide range of information sources. You should base your written response on the evidence in these documents and your knowledge of the process of photosynthesis.

Scenario: You are in physical science class when your phone starts chirping that it is low on battery. How terrible! As you take the bus home you hope it doesn't die before you get to your house. You race into the house and plug in your phone at the last minute. But the little charging symbol doesn't come one! "Oh no! Mom! What is going on?!" You yell. You then hear your Mom yelling in the kitchen. "What's wrong Mom!" She tells you about these "stupid brown outs!" and how "the lasagna for supper isn't going to be done on time because the stove can't draw enough electricity to keep the oven at the proper temperature." It looks like it is peanut butter sandwiches for you tonight! Your brother is in the living room and starts complaining about how the desktop computer just shut down unexpectedly because of the power loss and his homework was not saved. You remember your teacher talking about how the city's power plant can no longer keep up with the increased demand being placed upon it by your growing city. Is this what the future looks like? Will you ever Snap Chat again? You will die! So you decide to take up your teacher's offer to be on a committee to help decide how to increase your town's energy production and save texting for everyone.

Question-Product: Franklinville has many energy resources that can be used to produce electricity it will need in the future. However, the town is growing and has begun to experience brownouts during peak demand times. Franklinville's current energy portfolio is as follows: its electrical generating capacity is 1575 MW with an economic cost of 1,555 energy bucks ($) and an environment cost of 1,150 environ-units (EU) and the cost of electricity is $0.04/kWh. However, Franklinville's goals are to have its electrical generating capacity at 1,950 MW with an economic cost of 2,480 bucks and an environment cost of 1,170 EU and the cost of electricity stays the same, $0.04/kWh.

You and your classmates have joined a group of students, teachers, and community members to decide how to increase the production of electricity for Franklinville using one of the following energy sources: coal, geothermal, hydropower, nuclear power, solar, waste-to-energy, and wind. You are also going to evaluate the advantages and disadvantages of the energy sources used to generate electricity for the fictitious town and presenting the plans to the class as a video, pamphlet, or presentation to persuade voters in the upcoming election.

Energy Sources in Franklinville

COAL-Fired Plants: Coal is an abundant resource in Franklinville. The town has a 150-year supply of coal at the current rate of consumption. Half of the reserves, however, are located in wilderness areas.

To Build each Plant:

Capital Cost (to build):	*35$*
Operating and Maintenance (fixed):	*60$*
Operating and Maintenance (variable)	*7$*
Generating Capacity:	*65 MW*
Cost of Electricity:	*$0.04/kWh*

Geothermal Power Plants: Several high temperature geothermal plants could be built in a wilderness area named for the town's founder, who is buried there. It will cost $45 million to build a geothermal power plant.

To Build each Plant:

Capital Cost (to build):	*45$*
Operating and Maintenance (fixed):	*84$*
Operating and Maintenance (variable)	*10$*
Generating Capacity:	*5 MW*
Cost of Electricity:	*$0.05/kWh*

Hydropower Plants: The powerful Aichtuwoe River flows from the Osohi Mountains in the east through farmland and a national park to the western border of Franklinville.

To Build each Plant:

Capital Cost (to build):	*30$*
Operating and Maintenance (fixed):	*13$*
Operating and Maintenance (variable)	*0$*
Generating Capacity:	*50 MW*
Cost of Electricity:	*$0.01/kWh*

Natural Gas Plants: At present, there is no available natural gas supply in Franklinville to fuel natural gas power plants. Geologists believe there are deposits in the west; however, a production and distribution system must be built. This would increase the investment cost but also provide jobs.

To Build each Plant:

Capital Cost (to build):	*10$*
Operating and Maintenance (fixed):	*15$*
Operating and Maintenance (variable)	*3$*
Generating Capacity:	*40 MW*
Cost of Electricity:	*$0.04/kWh*

Nuclear Power Plants: Franklinville has an abundance of uranium that could be mined and processed, providing jobs for many people, if there were a demand. Many people are concerned about nuclear power plants because the town has no place at present to store the spent fuel. Due to this concern, only one plant can be built until a solution is reached.

To Build each Plant:

Capital Cost (to build):	*55$*
Operating and Maintenance (fixed):	*89$*
Operating and Maintenance (variable)	*2$*
Generating Capacity:	*220 MW*
Cost of Electricity:	*$0.03/kWh*

Solar Power Plants: The amount of solar radiation in all seasons and in all locations in the town makes it possible to use photovoltaic power plants to produce electricity. Solar systems, however, do not produce electricity 24 hours a day or every day of the year.

To Build each Plant:

Capital Cost (to build):	*50$*
Operating and Maintenance (fixed):	*17$*
Operating and Maintenance (variable)	*0$*
Generating Capacity:	*15 MW*
Cost of Electricity:	*$0.01/kWh*

Waste-to-Energy Plants: The non-recyclable trash in Franklinville is currently being landfilled. The combustible material in that trash (such as plastics, organic wastes, paper products, etc.) could be burned to produce electricity and reduce the amount of trash sent to landfills. There is enough combustible trash produced to fuel two power plants at the present time.

To Build each Plant:

Capital Cost (to build):	*40 $*
Operating and Maintenance (fixed):	*101 $*
Operating and Maintenance (variable)	*5 $*
Generating Capacity:	*5 MW*
Cost of Electricity:	*$0.04/kWh*

WIND FARMS: There are not many places in Franklinville that have consistent winds. Along the eastern mountains, however, the wind blows at a rate that would run wind machines most of the year. Some residents of the mountains would like to turn the area into a tourist area with resort hotels. W

To Build each Plant:

Capital Cost (to build):	*25$*
Operating and Maintenance (fixed):	*28$*
Operating and Maintenance (variable)	*7$*
Generating Capacity:	*10 MW*
Cost of Electricity:	*$0.05/kWh*

Master Energy Sources Spreadsheet with Formulas

Franklinville's Energy Goals:

1. Generating Capacity: 1,950 MW
2. Economic Cost: 2,480 energy bucks
3. Environment Cost: 1,170 enviro-units (EU)
4. Cost of Electricity: $ 0.04/kWh

1	A	B	C	D	E	F	G
	Energy Sources	Number of Power plants	Capital, Operating, and Maintenance Cost ($)	Generating Capacity (MW)	Environmental Impact Units (EU)	Cost of Electricity per kWh ($)	Total Cost of Electricity from this Source
2	Coal-Fired Plants	30	=B2*102	=B2*65	=B2*40	0.04	=D2*F2*1,000
3	Geothermal Power Plants	390	=B3*139	=B3*5	=B3*6	0.05	=D3*F3*1,000
4	Hydropower Dams	39	=B4*43	=B4*50	=B4*15	0.01	=D4*F4*1,000
5	Natural Gas Plants	49	=B5*28	=B5*40	=B5*30	0.04	=D5*F5*1,000
6	Nuclear Power Plants	9	=B6*146	=B6*220	=B6*25	0.03	=D6*F6*1,000
7	Solar Power Plants	130	=B7*67	=B7*15	=B7*3	0.10	=D7*F7*1,000
8	Waste-to-Energy Plants	390	=B8*146	=B8*5	=B8*6	0.04	=D8*F8*1,000
9	Wind Farms	195	=B9*60	=B9*10	=B9*2	0.05	=D9*F10*1,000

Blank Energy Sources Plan Spreadsheet

Franklinville's Energy Goals:

1. Generating Capacity: 1,950 MW
2. Economic Cost: 2,480 energy bucks
3. Environment Cost: 1,170 enviro-units (EU)
4. Cost of Electricity: $ 0.04/kWh

1	A	B	C	D	E	F	G
	Energy Sources	**Number of Power plants**	**Capital, Operating, and Maintenance Cost ($)**	**Generating Capacity (MW)**	**Environmental Impact Units (EU)**	**Cost of Electricity per kWh ($)**	**Total Cost of Electricity from this Source**
2	**Coal-Fired Plants**	**30**					
3	**Geothermal Power Plants**	**390**					
4	**Hydropower Dams**	**39**					
5	**Natural Gas Plants**	**49**					
6	**Nuclear Power Plants**	**9**					
7	**Solar Power Plants**	**130**					
8	**Waste-to-Energy Plants**	**390**					
9	**Wind Farms**	**195**					

Completed Energy Sources Plan Spreadsheet

Franklinville's Energy Goals:

1. Generating Capacity: 1,950 MW
2. Economic Cost: 2,480 energy bucks
3. Environment Cost: 1,170 enviro-units (EU)
4. Cost of Electricity: $ 0.04/kWh

1	A	B	C	D	E	F	G
	Energy Sources	Number of Power plants	Capital, Operating, and Maintenance Cost ($)	Generating Capacity (MW)	Environmental Impact Units (EU)	Cost of Electricity per kWh ($)	Total Cost of Electricity from this Source
2	Coal-Fired Plants	30	5,010	1,950	1,200	0.04	78,000
3	Geothermal Power Plants	390	54,210	1,950	2,340	0.05	97,500
4	Hydropower Dams	39	1,677	1,950	585	0.01	19,500
5	Natural Gas Plants	49	1,372	1,960	1,470	0.04	78,400
6	Nuclear Power Plants	9	1,314	1,980	225	0.03	59,400
7	Solar Power Plants	130	8710	1,950	390	0.10	195,000
8	Waste-to-Energy Plants	390	56,940	1,950	2,340	0.04	78,000
9	Wind Farms	195	11,700	1,950	390	0.05	97,5000

Facts about Energy Sources and Power Plants

Coal-Fired Plants

- Use an abundant domestic resource—coal.
- Burn coal—the mining of which can damage land and pollute water if not managed well.
- Emit some pollutants into the air when burned, even if advanced anti-pollution measures are installed.
- Produce carbon dioxide (CO_2) when burned.
- Use a nonrenewable resource.

Geothermal Power Plants

- Are built on the site of the geothermal reservoir.
- Produce few environmental impacts.
- Uses a renewable resource.

Hydropower Plants

- Require a lot of land be flooded for the reservoir, which can otherwise be used for recreational purposes.
- Can damage ecological habitats.
- Produce no air and minimal water pollution.
- Uses a renewable resource as fuel.

Natural Gas Plants

- Are excellent for peak load plants because they can be brought online and shut down quickly.
- Uses a clean burning fossil fuel, but still emit CO_2 and some pollutants into the air.
- Uses a nonrenewable resource (with undetermined reserves in Franklinville).

Nuclear Power Plants

- Uses small amounts of an economical and abundant energy resource.
- Produce no air or water pollution.
- Produce radioactive spent fuel that can be very dangerous and must be stored carefully at secure storage facilities.
- Uses a nonrenewable resource.

Solar Power Plants

- Cannot produce electricity all of the time.
- Produce no pollution but require large land areas.
- Use energy from the sun that is free to harvest.
- Use a renewable resource.

Waste-to-Energy Plants

- Burn trash to produce electricity.
- Reduce the need for landfill space.
- Produce CO_2 and other limited air pollutants when burned, and can smell bad.
- Use a renewable resource.

Wind Farms

- Requires a lot of land, but the land can also be used for other purposes.
- Does not produce electricity all of the time.
- Sometimes make noise and may impact bat and bird populations, but does not pollute the air or water.
- Uses an energy source that is free to harvest. Use a renewable resource.

Argument Instructional Model Worksheet

The Research Question:

Your Claim:

Your Evidence:

Your Justification of the Evidence:

Generating an Argument Writing Prompt Worksheet

In the space below, write an argument in order to persuade another biologist that your claim is valid and acceptable. As you write your argument, remember to do the following:

- State the claim you are trying to support
- Include genuine evidence (data + analysis + interpretation)
- Provide a justification of your evidence that explains why the evidence is relevant and why it provides adequate support for the claim
- Organize your argument in a way that enhances readability
- Use a broad range of words including vocabulary that we have learned
- Correct grammar, punctuation, and spelling errors

STUDENT RESPONSE SCORING RUBRIC

		EMERGING 0-2	DEVELOPING 3-4	MASTERY 5-6
ANALYTIC REASONING AND EVALUAITON	Interpreting, analyzing identifying information that is relevant to a problem, emphasizing connected and conflicting information, detecting flaws in logic and questionable , and evaluating the quality of information. This requires assumptions, and explaining why information is credible, unreliable, or limited	• Identifies very few facts or ideas that support or refute arguments presented in the Document Library. • Disregards or misinterprets much of the Document Library. • Does not make claims about the quality of information and present some unreliable information as credible.	• Identifies several facts or ideas that support or refute all major arguments presented in the Document Library. • Demonstrates accurate understanding of much of the Document Library content, but disregards some information. • Makes a few accurate claims about the quality of information.	• Identifies most facts or ideas that support or refute all major arguments presented in the Document Library. • Provides analysis that goes beyond the obvious. • Demonstrates accurate understanding of a large body of information from the Document Library. • Makes several accurate claims about the quality of information.
PROBLEM SOLVING	Considering and weighing information from separate sources to make decisions (draw conclusions) that logically follow from valid arguments, evidence, and examples.	• Provides or implies a decision but little rationale is provided or it is based on unreliable evidence.	• Provides a decision with credible evidence to back it up. Possibly does not account for credible, contradictory evidence.	• Provides a decision and a solid rationale based on credible evidence from a variety of sources. Weighs other options, but presents the decision as best given the available evidence.
EVIDENCE AND EXPALANTION	Constructing organized and logically cohesive arguments. Strengthening the writer's position by providing elaboration on facts or ideas (e.g. explaining how evidence bears on the problem, providing examples, and emphasizing especially convincing evidence).	• Provides limited, invalid, overstated, or very unclear arguments. • May present information in a disorganized fashion or undermine own points. • Any elaboration on facts or ideas tends to be vague, irrelevant, inaccurate, or unreliable (e.g. based entirely on writer's opinion). Sources of information are often unclear.	• Organizes response in a way that makes the writer's arguments and logic of those arguments apparent but not obvious. • Provides valid elaboration on facts or ideas related to each argument and cites sources of information.	• Organizes responses in a logically cohesive way that makes it very easy to follow the writer's arguments. • Provides a valid and comprehensive elaboration of facts and ideas related to each argument and clearly cites sources of information.
AUTHENTIC TASK		• The written argument is brief and may contain numerous grammatical errors. • The writing is difficult to understand • Ideas do not connect or show logical progression supporting a particular claim.	• Writing may have a few grammatical errors • The claim and supporting evidence needs some improvement for the reader to understand the writer's point • In general the writing indicates some understanding and ability to support a claim.	• Excellent grammar. • The claim and supporting evidence are easily understandable by the reader. • The writing follows a logical progression in support of the claim.

Annotated Bibliography/Resources

Achieve Inc. (2013). *Next generation science standards.* Retrieved from www.nextgenscience.org/next-generation-science-standards

A national document that contains new education standards in different science subjects to help students deeply understand core scientific standards.

Common Core State Standards Initiative and Others. (2012). *Common core state standards for English language arts & arts literacy in history/social studies, science, and technical subjects.* Washington, DC: NGC Center/CCSSO.

The Common Core State Standards Initiative is an educational initiative in the United States that details what K–12 students should know in English language arts and mathematics at the end of each grade.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: National Academies Press.

The National Research Council (NRC) recommendations on key science ideas and practices that all students should learn in primary and secondary school

NEED. (2013). *Mission Possible.* Masassas: The NEED Project.

This is a curriculum unit in which students work in small groups to develop an energy plan to provide more electricity to a growing country.

Sampson, V., & Grooms , J. (Summer 2010). Promoting and supporting scientific argumentation outside of the lab . *The Science Teacher* , 32-37.

This article describes how to implement an instructional model of science argumentation called Generate an Argument. The article includes an example of Generate an Argument activity.

Sampson, V., & Sharon, S. (2013). *Scientific argumentation in biology: 30 classroom activities* . Arlington : NSTA .

This book contains 30 activities on science argumentation including assessments, rubrics, examples of student arguments, and teacher notes.

Sampson, V., Enderle, P., & Jonathon, G. (Summer 2013). Argumentation in science education: Helping students understand the nature of scientific argumentation so they can meet the new science standards. *The Science Teacher* , 30-33.

This article explains the different components of science argumentation and encourages science teachers to use science argumentation in the classroom to help students better understand the nature of science and meet the new science standards.

Appendix/Content Standards

Taken from Pennsylvania Department of Education Standards Aligned System

Physical Science.

4.2.10.A: Explain that renewable and nonrenewable resources supply energy and materials.

4.2.10.B: Evaluate factors affecting availability of natural resources.

4.2.12.A: Analyze the use of renewable and nonrenewable resources.

4.2.12.B: Analyze factors affecting the availability of renewable and nonrenewable resources.

4.8.10.C: Analyze how human activities may cause changes in an ecosystem.

4.8.10.D: Explain how the concept of supply and demand affects the environment.

4.8.12.C: Analyze how pollution has changed in quality, variety and toxicity as the United States developed its industrial base.

4.8.12.D: Analyze the international implications of environmental occurrences.