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Energy Bill, Part 2: The Real Cost of Energy

Instructor's Guide and Answer Key

Objectives:

- Students will understand the variety of resources used to produce the energy they consume.
- Students will understand the difference between nonrenewable and renewable energy resources.
- Students will understand difference between primary and secondary sources of energy.
- Students will work with current energy statistics in tabular and graphical forms.
- Students will understand the resources and emissions consequences of their personal energy use.
- Students will understand the resources and emissions consequences of energy savings efforts.

The Main Thing:

In Energy Bill, Part 1 your students probably got their first, thorough look at some imaginary, but typical energy bills. That lesson was specifically intended to prepare your class for Energy Bill, Part 2. This lesson begins with students learning the difference between nonrenewable and renewable energy resources, and primary vs. secondary sources of energy. Then Part 2 takes students to a review of the resources and air emissions consequences of their energy bill. Finally, and most importantly, students will understand the resources and emissions consequences of their energy savings efforts. Together, these two lessons do a great job of setting the stage for all other energy related lessons and activities that follow.

Activity and Teacher Notes:

Energy Bill, Part 1 – The Cost of Energy is a prerequisite for this lesson. Students should have completed **Part 1** and be prepared for this follow-up.

Energy Bill, Part 2 – The Real Cost of Energy is designed to teach concepts, ideas, and facts seldom talked about in the context of an energy bill. For this reason, they are largely ignored. But like it or not, they are always present—just beyond the last page of every energy bill ever sent.

First time teachers of this lesson should perform the lesson as students before using it. In this way new teachers can thoroughly acquaint themselves with the lesson content, dynamics, timing, and assessment. Performing this lesson as a student will also give you good ideas on where you may want to place additional introduction, conclusion, concept, or discussion emphasis.

Though **Energy Bill, Part 2** is designed to be student led (and therefore ideal for online, hybrid, and flipped classroom instruction), there are places where you must lead and be available for questions and discussion.

The first and most obvious place for this is the introduction. **Energy Bill, Part 2** begins for students—and you—with definitions for primary vs. secondary energy resources, and nonrenewable vs. renewable energies.

Introduce your students to these definitions, answering any questions students may have. The difference between primary and secondary energy resources is pretty straightforward. However, many students have not been introduced to these terms before. Similarly, most students doing a lesson of this kind can cite a few examples of renewable energy technologies. Not as many students have ever had definitions placed in front of them.

- **Renewable energy resources:** Energy resources that are replaced by natural processes at a rate comparable to their use.
- **Nonrenewable energy resources:** Energy resources that are limited and can eventually run out. These sources of energy cannot be replaced by natural processes on a time span of human significance.

You'll need to carefully review these definitions with your students. Highlight these phrases within the definitions if students don't ask questions about them:

- "natural processes"
- "at a rate comparable to their use"
- "on a time span of human significance"

Students will match these definitions to a variety of energy resources upon visiting the **United States Environmental Protection Agency (EPA) Power Profiler** website. Not surprisingly, some students do this more easily than others. As you will see in the lesson, students are called upon to have you check that they've matched these definitions to the energy producing technologies correctly.

In the middle of this lesson, you'll need to communicate four pieces of information to your students. They are lbs. of CO₂ Equivalent and lbs. of Coal Burned for the consumer use of both 1 KWH of electricity and 1 Therm of natural gas. Students will place these values into a table in their lesson and use them as calculation conversions.

To get this information for your students in its most accurate and current form, navigate to the US EPA Greenhouse Gas Equivalency Calculator:

<https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>

Upon arriving, follow these directions to get the information you need:

The screenshot shows the EPA Greenhouse Gas Equivalency Calculator interface. At the top, there is a navigation bar with 'Environmental Topics', 'Laws & Regulations', and 'About EPA'. Below this is the title 'Energy and the Environment' and 'Greenhouse Gas Equivalencies Calculator'. A sub-header 'Greenhouse Gas Equivalencies Calculator' is followed by a small icon and the text 'Last Updated: March 2020'. The main content area is titled 'Enter Your Data' and contains instructions on how to use the calculator. A box highlights the input fields: 'If You Have Energy Data' and 'If You Have Emissions Data'. The 'Energy Data' field is set to '1' and the 'Emissions Data' field is set to 'therms of natural gas'. A 'Calculate' button is visible. Below the input fields, the 'Equivalency Results' section shows the sum of greenhouse gas emissions as '11.7 Pounds'. A box highlights this result and the unit 'Pounds'. Another box highlights the 'Pounds of coal burned' category in the 'CO₂ emissions from' section, with a note to change the unit from 'Metric Tons' to 'Pounds' to get the information needed.

Calculate for:

- 1 kilowatt-hour of electricity
- and
- 1 therm of natural gas

Calculate

Equivalency Results

The sum of the greenhouse gas emissions you entered above is of Carbon Dioxide Equivalent. This is equivalent to: 11.7 Pounds

Greenhouse gas emissions from

- 0.001 Passenger vehicles driven for one year
- 13.1 Miles driven by an average passenger vehicle

CO₂ emissions from

- 0.595 gallons of gasoline consumed
- 0.52 gallons of diesel consumed
- 5.8 Pounds of coal burned
- 0.0001 tanker trucks worth of gasoline

Change this unit from Metric Tons to Pounds to get the information you need (circled)

Here is a copy of the student table into which you may place the needed values.

Quantity of Energy	Lbs. CO ₂ Equivalent*	Lbs. Coal Burned**
1 KWH	*	*
1 Therm	*	*

Following are the definitions for the lbs. of CO₂ Equivalent and lbs. of Coal Burned found in the student lesson. They are a little tricky, so you may want to spend some time on the Greenhouse Gas Equivalencies Calculator website to familiarize yourself with them. You'll need to carefully review these definitions with your students when you provide them with the values they need in the lesson. Our definitions are simpler than explained on the website, but they are accurate.

***Pounds of Carbon Dioxide Equivalent** defines the mass of CO₂ that would have the same warming potential as a given *mixture* of emissions for the consumer use of a stated quantity of energy.

****Pounds of Coal Burned** is the average mass of coal—and only coal—that would have to be burned to produce some stated quantity of energy.

After providing the values and definitions, you may want to spend some time showing your students how to do some of the calculations that follow. You will have done them already. Decide to keep, remove, change, or add to the math prompts shown. Be available to help your students as needed as they move through this critical section.

Lesson Summary Questions may be completed in class or as homework. Accuracy of student math work and objective answers should be checked. Discussion of student answers to the **Lesson Summary Questions** is naturally fertile. Consider taking advantage of this discussion to reinforce and extend other energy use concepts.

An answer key to the **Lesson Summary Questions** follows. You are of course, welcome to add, subtract, or alter the questions provided. As written, the questions are designed to stress the:

- Fundamental differences between renewable and nonrenewable energy resources.
- Fundamental differences primary and secondary sources of energy.
- Personal resources and air emissions consequences of energy use.
- Personal resources and air emissions consequences of energy savings efforts.

The teacher of this lesson will have to decide on an individual or group approach to its completion. If a group approach is chosen, it is still expected that each student individually complete the written exercises.

Instructor's Answer Key (to the Lesson Summary Questions)

1. Consider your answers for numbers 19 and 20 in the procedure. Why are renewable energy resources considered to be “clean energy” technologies?

* **This is not an easy student question number one to answer. However, this seems the perfect place to ask students to reason this question through. In the final part of the lesson procedure, students were required to calculate lbs. of coal burned and lbs. of CO₂ equivalent put into the air by a typical area family—maybe a family just like theirs. Once up and running, these inputs and outputs are required of all nonrenewable energy resources. Once up and running, these inputs and outputs are *not* required of renewable energy resources. Plainly, this makes renewables clean energy technologies. Help students tie what they have just calculated and learned into their answer for this question.**

2. Which renewable energy technology do you believe, has the greatest potential to increase in your area in the next 5-10 years? A little research may be required to write a good answer. A good answer will also require you to organize your writing.

* **This is a judgement question. Student reasoning should be evident in a good answer. Some student research will probably be required.**

3. Natural gas may be burned and used directly in a home for space heating. Natural gas is also used to make electricity. In this way it can also be used indirectly for space heating with an electric heater. Use what you learned on page one of this lesson to answer the following question.

Fundamentally, what is the difference between natural gas used directly for space heating, and natural gas used indirectly for space heating with an electric heater?

You must use the phrases *primary energy resource* and *secondary energy resource* in your answer to question 3.

* **Used for space heating in a home, natural gas is being used directly as a primary energy resource. Used to make electricity for a home, natural gas is being used as a primary source of energy to make a secondary energy resource—electricity.**

4a. List all of the primary sources of energy employed to produce the electricity you use:

* **The sources will vary by eGRID subregion.**

4b. Which primary source were you most surprised to find produces electricity for your area?

* **This is a judgement question.**

4c. Explain why it was a surprise to you.

* **This is a judgement question. Student reasoning and reaction should be evident in a good answer.**

5a. Enter primary resources in the top 5 and bottom 5 for your eGRID in **Table A**.

Table A.

Resource fuel from my eGRID Subregion in the <i>top 5</i> nationally for generating electricity	Resource fuel from my eGRID Subregion in the <i>bottom 5</i> nationally for generating electricity
*	*
*	*
*	*

5b. Describe something meaningful and significant where you live for each of the resources listed in your eGRID top 5 or bottom 5. A little research may be required to write a good answer. A good answer will also require you to organize your writing.

* **This is a reflection and judgement question. Student reasoning and reaction should be evident in a good answer. Some student research will probably be required.**

6. Briefly describe why each of these waste gases is considered significant enough that their release is measured and recorded. A little research may be required to write a good answer. Good answers will also require you to organize your writing.

The information that follows is not written to provide model student answers. It is provided here for teacher consumption. The question above asks students to “Briefly describe...” Student answers should be expected to provide some of the following information in a short, intellectually honest, student form.

6a. CO₂, carbon dioxide:

* Carbon dioxide is given off through many natural earth and biological processes. It is also released in burning fossil fuels, biomass, wastes, and as a result of some industrial chemical reactions. It is one of several primary gases controlling the earth's temperature. These gases permit sunlight to enter through our atmosphere. Once it enters, much of the sun's radiation is then converted to heat. Carbon dioxide and other gases are capable of absorbing some of this heat before it leaves the atmosphere and escapes into space. The balance of heat staying in our atmosphere and heat leaving our atmosphere regulates earth's surface temperature. Many scientific studies indicate excess CO₂ and other gases have increased earth's surface temperature by trapping excess heat in the atmosphere.

6b. SO₂, sulfur dioxide:

* Sulfur dioxide is given off through many natural earth processes. It is also released in the burning sulfur-containing fossil fuels, biomass, wastes, and as a result of some industrial processes. SO₂ and other sulfur oxides can react with water vapor and other compounds in the atmosphere to produce acid rain. Acid rain can be harmful to vegetation (including crops), and to waterways and their inhabitants.

6c. NO_x, nitrogen oxide:

* Nitrogen oxides are given off through several natural earth processes. They are also released in burning nitrogen-containing fossil fuels, biomass, wastes, and as a result of some agricultural and industrial processes. NO_x gases can react with water vapor and other compounds in the atmosphere to produce photochemical smog, or acid rain. Fine particulate matter (PM) and ground level ozone may also be formed. Both of these are associated with adverse human health effects, especially in people who already suffer from lung diseases.

7a. Enter the waste gases released to the atmosphere you found were in the top 5 and bottom 5 for your eGRID in **Table B**.

Table B.

Waste gases from my eGRID Subregion in the <i>top 5</i> nationally for generating electricity	Waste gases from my eGRID Subregion in the <i>bottom 5</i> nationally for generating electricity
*	*
*	*

7b. Describe something meaningful and significant where you live for each of the waste gases in your eGRID top 5 or bottom 5. A good answer will require you to organize your writing.

***** This is a reflection and judgement question. Student reasoning and reaction should be evident in a good answer. Some student research will probably be required.

8. Without too much trouble, you can probably come up with several actions that will save energy for most families. Describe five actions that can save meaningful amounts of energy on a family's energy bill.

Hopefully, many good student answers will come from this question. Stress that these answers should save *meaningful* amounts of energy. Some student research may be required. Student discussion on answers is always interesting and stimulating.

8-1. *

8-2. *

8-3. *

8-4. *

8-5. *

9. When you save energy, what else are you saving at the same time?

***** *Money savings* will be the first answer. But just as important—and key to measuring understanding of this lesson—is that students add the words (or ideas) that *resources* and *emissions* are saved as well. Saving energy saves all three at the same time!

10 & 11. Consider your calculations for numbers 19 and 20 in the procedure. For number 19, you calculated the pounds of coal burned to provide the family with energy this year.** For number 20, you calculated the pounds of CO₂ emissions released to the air to provide the family with energy this year.*

But then, this family put your energy savings ideas from question 6 into practice! Doing so, saved them 10% of the energy they had been using.

10a. Using this information, calculate the new total pounds of coal burned to provide the family with energy this year.

* **90% of answer to number 19**

10b. Using this information, calculate the pounds of Coal that were never burned because of the 10% energy savings.

* **10% of answer to number 19**

11c. Using this information, calculate the new total pounds of CO₂ emissions released to the air to provide the family with energy this year.

* **90% of answer to number 20**

11b. Using this information, calculate the pounds of CO₂ emissions that were never released to the air because of the 10% energy savings.

* **10% of answer to number 20**

12. Look at your answer to question 9 again. Make sure your answer to that question is complete based upon your answers to questions 10 and 11.

* **Money savings will be the first answer to number 9. But just as important—and key to measuring understanding of this lesson—is that students add the words (or ideas) that *resources* and *emissions* are saved as well, especially after doing questions 10 & 11. Saving energy saves all three—in significant amounts—at the same time!**

13. Describe the most important idea, concept, principle, or fact you learned while completing this lesson. Explain why your idea, concept, principle, or fact is important for you (and probably other people) to know and understand.

* **This is a reflection and judgement question. Student reasoning and reaction should be evident in a good answer. No two student answers should be the same.**