Energy Audit

Calculating Household Energy Use and Greenhouse Gas Emissions

Description

Students investigate the relationship between energy use and climate change by conducting an energy audit of common household appliances. They calculate the amount of carbon dioxide released into the atmosphere through their use of these household appliances.

Phenomenon

Human behavior is changing Earth's atmosphere and affecting the climate.

Objectives

Students will:

- Identify the human behavior (energy production and use) that is changing the Earth's atmosphere
- Measure the energy use of several household appliances
- Calculate personal contribution of carbon dioxide to the atmosphere through their use of specific appliances
- Summarize how energy production has contributed to climate change

Grade Level

5 – 8

Time

1 Hour

Materials

- *Energy Audit* handout [1 per student]
- PowerPoint presentation
- Computer and projector*
- Calculators* [1 for every 1-4 students]
- Power meters [8]
- Assortment of 5-10 small appliances and electronics*, preferably some that students would have in their homes
  - Appliances that heat up work well because they use a relatively large amount of energy. It is ideal to include at least two such appliances. Examples: microwave, hair dryer, toaster, toaster oven.
  - Other possible appliances/electronics: television, DVD player, cable box, blender, coffee maker, electric mixer, food processor, computer, projector, printer, tablet (charging), cell phone (charging), lamp.
  - If desired, students can bring appliances from home to test.

* Not included in kit

Background

Now that students have learned about how a changing atmosphere affects the greenhouse effect on Earth, they will explore the human behavior creating that change. The goal for this activity is for students to connect human behavior, specifically energy production and use, to the atmospheric changes modeled in Insulating You, Insulating Earth. Students will accomplish this by measuring the energy use of common

household appliances and calculating the amount of CO_2 emitted to the atmosphere through their use of these appliances.

According to the Energy Information Administration, New Mexico used 120 trillion British thermal units (Btu) of energy in 2018 in the residential sector (http://www.eia.gov/state/?sid=NM#tabs-2). This sector includes private dwellings such as homes and apartments. The residential sector accounts for 17% of the total energy consumption. While three other sectors account for higher energy consumption percentages (industrial 33%; transportation 32%; and commercial 18%), the residential sector is where students can most clearly measure their contribution to changes in atmospheric composition and climate change.

The sources for more than 90% of the energy currently used in New Mexico are fossil fuels, including natural gas, coal, and oil. Fossil fuels form from the remains of dead organisms that have been buried and placed under high heat and pressure for millions of years. In power plants, fossil fuels are burned to boil water, generating steam used to drive large turbines that create electricity. In addition to electricity, power plants emit large quantities of carbon dioxide into the atmosphere. As we saw in Insulating You, Insulating Earth, carbon dioxide is a greenhouse gas; more of it in the atmosphere causes more of the re-radiated thermal energy from Earth to be re-emitted back to the planet instead of escaping into space. This enhanced greenhouse effect is causing average global temperatures to increase.

Students can measure the amount of electricity used by appliances in their houses to gauge their impact on global warming. As an extension to the Energy Audit, you can have your students measure the energy use of appliances while they are off. They will discover some "energy vampires," including appliances with a remote control, a rechargeable battery, or a digital status light or clock, which use energy even while off. Unplugging these energy vampires and reducing the use of all electronic appliances can save significant amounts of electricity. These actions will result in burning less fossil fuel and lower carbon dioxide emissions.

Tips for Entire Class Participation

- Have students work in up to eight small groups to collect data. There are eight power meters in your kit. The number of students per group will be determined by your class size and the number of appliances you have available to test.

Preparation

1. Place appliances around the room, near outlets, so that groups can rotate between appliances to test them.
2. Write the names of the appliances that students will be testing on the board.
3. Draw the class data table (from page 2 of the student handout) on the board or prepare to show it with a document camera.
4. Set up computer and projector to display the PowerPoint.

Teaching Guide

Introduction to the Energy Audit (~10 minutes)

1. Slide 1: Explain that we will measure the energy use of several small household appliances to test which one uses the most energy. Explain that students will use the data collected to calculate how much CO_2 their own behavior (using these appliances at home) emits to the Earth's atmosphere in just one year. While this is a small sliver of total energy use, it will help students better understand their personal impact on the environment.
2. Slide 2: Show students a power meter and explain that it measures an appliance's energy use in watts. Power describes the rate at which energy flows, and a watt is a unit that represents the power of something. Appliances use energy at different rates, so something that uses energy

faster will have a higher watt value. The power meter is plugged into the wall. Students push the "function" button on the power meter until it reads "W" in the middle section and "COST" on the bottom. Then students will plug an appliance into the front of the meter.

3. Tell students that they will record their data in watts in the data table on page 1 of the handout. Explain that they will turn on each appliance and record the number of watts used as it is running. Have students write the names of the appliances they're testing in the data table on page 1. Explain that as they conduct their energy audit (or systematic review of the energy use of each appliance), they will complete the first three columns (A, B, and C) of the data table (shaded in grey). After they have written the name of the appliance, they record the wattage while in use, and lastly, estimate how many hours per week they use the appliance at home. These time estimates can be recorded in fractions of an hour.

Conducting the Energy Audit (~15 minutes)

1. Break students into eight groups and give each group a power meter. Tell them to measure the energy use for each appliance and estimate how many hours per week they use that appliance.
2. Help groups get started, making sure that they are filling out the energy audit table completely.

Discussion of Energy Production and the Greenhouse Effect (~10 minutes)

1. Slide 3: Remind students that greenhouse gases exist in the atmosphere (carbon dioxide, water vapor, ozone, methane, nitrous oxide, and fluorinated gases). These gases absorb and then re-radiate infrared radiation (thermal energy) in Earth's atmosphere. These gases exist naturally in Earth's atmosphere and were modeled by the towel in Insulating You, Insulating Earth.
2. Slide 4: Briefly review the greenhouse effect diagram, reminding students that the enhanced greenhouse effect (caused by increased greenhouse gases in the atmosphere and modeled by the towel and Mylar blanket in Insulating You, Insulating Earth) results in warmer temperatures.
3. Slide 5: Remind students that humans release more carbon dioxide than any other greenhouse gas (76% total, including 65% from burning fossil fuels and 11% from deforestation and other land use).
4. Slide 6: The majority of carbon dioxide is emitted from electricity generation (25%). This is a significant human behavior that changes the Earth's atmosphere and affects climate.
5. Slide 7: Non-renewable sources make most of the electricity production in the United States, and the most common are coal and natural gas.
6. Slide 8: Review how coal-fired power plants work by burning coal to make steam. The steam turns a turbine that generates electricity. When coal burns, the carbon stored in the coal is released in the form of carbon dioxide.
7. Slide 9: Natural gas power plants also usually work by burning natural gas to make steam, which is run through a turbine to generate electricity. Burning natural gas releases less carbon dioxide than burning coal. However, natural gas is methane, which is a more potent greenhouse gas than carbon dioxide. Leaks at natural gas power plants release methane, causing concerns about using natural gas to make electricity.
8. Slide 10: Remind students that carbon dioxide in the atmosphere has been measured at Mauna Loa Observatory since 1956 and ask them to describe the trend of this graph. Ask students how they think this increase connects to the production of electricity.
9. Slide 11: Remind students of this graph of global average temperature since 1880. Ask them how they think the increase connects to carbon dioxide in the atmosphere. [answer: increasing carbon dioxide, a greenhouse gas, means more re-radiated thermal energy from Earth is re-emitted back to the planet instead of escaping into space.]

Calculating Personal Emissions (~25 minutes)

1. Slide 12: Direct students to complete the remaining columns (D-G) of the data table on page 1 of the handout. For each appliance, have students calculate the amount of carbon dioxide (kg) emitted to the atmosphere with one year of personal use and then determine their total yearly carbon dioxide emissions using the appliances tested. Students should complete the following calculations for each appliance tested that they use at home:
    a. Column D: Multiply the wattage (Column B) by the estimated number of hours students use the appliance in one week to determine the watt-hours per week.
    b. Column E: Multiply the watt-hours per week (Column D) by 52 weeks per year to determine the watt-hours per year.
    c. Column F: To determine kilowatt-hours per year, divide watt-hours per year (Column E) by 1000.
    d. Column G: Multiply the kilowatt-hours per year by 0.58 kg to calculate the amount of carbon dioxide released through the use of these appliances. This figure comes from the most recent year of data for New Mexico energy production from the U.S. Energy Information Administration (https://www.eia.gov/electricity/state/newmexico). Producing 1 kWh of electricity in New Mexico releases 0.58 kg of carbon dioxide.
    e. At the bottom of column G, have students add up the carbon dioxide total to determine the total emissions from their use of these household appliances in one year.
    f. Have students respond to question 1 on page 2 of the handout.
2. Once students have calculated their personal emissions, have them add it to the whole class data table on the board. This data table is also found on page 2 of the handout, and students should record their classmates' data as they report them. Add the class total for emissions in one year using these common household appliances in question 2 on the handout.
3. Continue to expand the scale in which students look at energy use by having them answer question 3 in the conclusion section of the handout. Students will consider the carbon dioxide emissions in one year if every student in their grade in New Mexico used the same amount of electricity through these household appliances. In New Mexico, there is an average of 25,000 students per grade level.
4. Further increasing the scale, have students respond to questions 4 and 5 considering the global population increase, energy use, and the environmental consequences of this human behavior. Encourage students to think about ways, besides residential electricity use, that humans use energy, such as transportation or industry.
5. Finish the lesson by having students brainstorm ways they could reduce their personal energy use at home and respond to question 6.

Extensions

1. Guide students through calculating how much carbon dioxide they could save from the atmosphere by reducing their use of specific appliances. Ask students to think about how many hours per day they could personally reduce the use of one appliance they tested today. For example, if they tend to leave the TV on when no one is in the room, could they turn it off for two hours instead? Alternatively, ask students to think of an appliance that uses energy while plugged in but not in use. Could they unplug it when it's not in use? For example, if they usually leave a DVD player with a digital clock plugged in all the time, even though they only use it once a week, could they unplug it when it is not in use?
2. Once students have chosen an appliance, have them note the wattage value of that appliance and the number of hours per day they could reduce the use of the appliance or unplug the appliance when not in use.
3. Ask students to indicate how many days per week they could do their chosen action.
4. Using the same steps from the data table on page 1, have students calculate how much carbon dioxide they could save from the atmosphere if students reduced their use of a chosen household appliance.

5. Have students share their chosen action and amount of saved carbon dioxide with the class to further discuss reducing energy use as a possible solution to climate change.
6. Allow students to check out power meters to test appliances at home and report their findings.