# Energy Audit

***Calculating and Reducing Household Energy Use***

## 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 that could be kept out of the atmosphere by reducing energy use.

## Grade Level

5 – 12

## Objectives

Students will:

- Measure the energy use of several household appliances
- Calculate the potential reduction of energy use and carbon dioxide emissions by conscientious use of appliances
- Summarize how energy production has contributed to climate change

## Time

1 Hour

## Common Core State Standards

English Language Arts Standards >> Reading: Informational Texts >> Grade 5
CCSS.ELA-LITERACY.RI.5.4: Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 5 topic or subject area.

English Language Arts Standards >> Science & Technical Subjects >> Grade 6-8
CCSS.ELA-LITERACY.RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
CCSS.ELA-LITERACY.RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

English Language Arts Standards >> Science & Technical Subjects >> Grade 9-10
CCSS.ELA-LITERACY.RST.9-10.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
CCSS.ELA-LITERACY.RST.9-10.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.

English Language Arts Standards >> Science & Technical Subjects >> Grades 11-12
CCSS.ELA-LITERACY.RST.11-12.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
CCSS.ELA-LITERACY.RST.11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.

Mathematics Standards >> Statistics & Probability >> Grade 6
CCSS.MATH.CONTENT.6.SP.B.5: Summarize numerical data in relation to their context, such as by: B. Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.

## New Mexico State Science Standards

(Strand – Standard – Benchmark – Performance Standard)
5th Grade
1-1-1-1: Plan and conduct investigations, including formulating testable questions, making systematic observations, developing logical conclusions, and communicating findings.
1-1-1-2: Use appropriate technologies (e.g., calculators, computers, balances, spring scales, microscopes) to perform scientific tests and to collect and display data.
1-1-1-3: Use graphic representations (e.g., charts, graphs, tables, labeled diagrams) to present data and produce explanations for investigations.
1-1-3-1: Use appropriate units to make precise and varied measurements.
1-1-3-2: Use mathematical skills to analyze data.
1-1-3-3: Make predictions based on analyses of data, observations, and explanations.
2-2-1-4: Describe how human activity impacts the environment.
3-1-1-1: Describe the contributions of science to understanding local or current issues (e.g., watershed and community decisions regarding water use).

6th Grade
1-1-1-3: Justify predictions and conclusions based on data.
2-3-2-5: Understand factors that create and influence weather and climate, including: factors that can impact Earth's climate (e.g., volcanic eruptions, impacts of asteroids, glaciers).
3-1-1-1: Examine the role of scientific knowledge in decisions (e.g., space exploration, what to eat, preventive medicine and medical treatment).



Developed by the Asombro Institute for Science Education (www.asombro.org)

7th Grade
1-1-3-2: Use mathematical expressions to represent data and observations collected in scientific investigations.
2-1-2-1: Know how various forms of energy are transformed through organisms and ecosystems, including: effect of mankind's use of energy and other activities on living systems (e.g., global warming, water quality).

8th Grade
1-1-1-2: Use a variety of technologies to gather, analyze and interpret scientific data.
1-1-3-1: Use mathematical expressions and techniques to explain data and observations and to communicate findings (e.g., formulas and equations, significant figures, graphing, sampling, estimation, mean).
3-1-1-2: Describe how scientific information can help to explain environmental phenomena (e.g., floods, earthquakes, volcanoes, fire, extreme weather).
3-1-1-3: Describe how technological revolutions have significantly influenced societies (e.g., energy production, warfare, space exploration).
3-1-1-4: Critically analyze risks and benefits associated with technologies related to energy production.

9th – 12th Grade
1-1-1-2: Design and conduct scientific investigations that include: testable hypotheses, controls and variables, methods to collect, analyze, and interpret data, results that address hypotheses being investigated, predictions based on results, re-evaluation of hypotheses and additional experimentation as necessary, error analysis.
1-1-1-3: Use appropriate technologies to collect, analyze, and communicate scientific data (e.g., computers, calculators, balances, microscopes).
1-1-1-4: Convey results of investigations using scientific concepts, methodologies, and expressions, including: scientific language and symbols, diagrams, charts, and other data displays, mathematical expressions and processes (e.g., mean, median, slope, proportionality, clear, logical, and concise communication, reasoned arguments).
2-2-1-4: Critically analyze how humans modify and change ecosystems (e.g., harvesting, pollution, population growth, technology).
2-3-2-11: Explain how layers of the atmosphere (e.g., ozone, ionosphere) change naturally and artificially.
3-1-1-3: Evaluate the influences of technology on society (e.g., communications, petroleum, transportation, nuclear energy, computers, medicine, genetic engineering) including both desired and undesired effects, and including some historical examples (e.g., the wheel, the plow, the printing press, the lightning rod).

## Next Generation Science Standards

5th Grade
5-ESS3-1: Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Middle School
MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
MS-ESS3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
MS-ESS3-5: Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

High School
HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

**Materials**

- *Energy Audit* handout [1 per student]
- PowerPoint presentation
- Computer and projector*
- Calculators* [1 for every 1-4 students]
- Kill-a-Watt 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.

* Not included in kit

## Background

According to the Energy Information Administration, New Mexico used 117.4 trillion British thermal units (Btu) of energy in 2014 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 34%; transportation 31%; and commercial 18%), the residential sector is the one that can be most influenced by students and their actions.

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 are formed from the remains of dead organisms that were buried and placed under high heat and pressure for millions of years. In power plants, fossil fuels are burned to boil water, generating steam that is used to drive large turbines that create electricity. In addition to electricity, power plants emit large quantities of carbon dioxide into the atmosphere. Since 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. Some appliances use energy even when they are turned off. These "energy vampires" include appliances with a remote control, a rechargeable battery, or a digital status light or clock. Unplugging these appliances and/or reducing use of appliances can save large amounts of electricity. This 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 Kill-a-Watt 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. Spread out 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 3 of the student handout) on the board or prepare to show it with a document camera.
4. Decide on the number of students to use for analysis question 8.
    a. You can use the average number of students per grade in New Mexico (approximately 25,000 students per grade).
    b. Alternatively, you can use other student numbers (e.g., number of students in your school district) that can be found on the New Mexico Public Education Department website in the school fact sheets: http://www.ped.state.nm.us/IT/schoolFactSheets.html
    c. Write whichever estimate you would like students to use for analysis question 8 on the board.
5. Set up computer and projector to display PowerPoint.

## Teaching Guide

### *Introduction to the Energy Audit (~10 minutes)*

1. Explain that we will be measuring the energy use of several small household appliances to test which one uses the most energy and to see if any appliances use energy even when they are turned off.

2. Slide 2: Show students a Kill-a-Watt meter and explain that it measures an appliance's energy use (in watts). The Kill-a-Watt meter is plugged into the wall. Students push the "watt" button on the Kill-a-Watt meter and then 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 the handout.
4. Have students look at the data table on page 1 of the handout. Explain that they will record the number of watts shown on the meter while the appliance is off, and then they will turn it on and record the number of watts used.
5. Direct students to the prediction question on the handout. Ask them to copy the list of appliances that they will be testing from the board and circle the ONE that they think will use the most energy.

### *Procedures: Conducting the Energy Audit (~20 minutes)*

1. Break students into up to eight groups, and give each group a Kill-a-Watt meter. Tell them to measure the energy use for each appliance. Remind them that the procedures are listed on page 1 of the handout.
2. Help each group get started with their first appliance and be sure that they are filling out the energy audit table completely.

### *Procedures: Discussion of Energy Production (~10 minutes)*

1. Slide 3: Remind students that there are greenhouse gases 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.
2. Slide 4: Briefly review the greenhouse effect diagram, reminding students that the enhanced greenhouse effect (caused by increased greenhouse gases in the atmosphere) has resulted in warmer temperatures and climate change.
3. Slide 5: Remind students that humans release more carbon dioxide than any other greenhouse gas (77% total, including 57% from burning of fossil fuels, 17% from deforestation and other decay of biomass, and 3% from other sources).
4. Slide 6: More carbon dioxide is emitted from electricity generation (40%) than from any other cause.
5. Slide 7: The most common sources for electricity production in the United States 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 is burned, a lot of carbon that was 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 since 1956 and ask them to describe the trend of this graph. Ask students how they think this increase is connected to the production of electricity.
9. Slide 11: Remind students that the global average temperature has been measured since 1880 and ask them how they think the increase is connected 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.]

### *Results and Analysis (~20 minutes)*

1. Direct students to answer results questions 1 and 2 on the handout.

2. Have students answer analysis question 1 on the handout.
3. Slide 12: Guide students through the calculations for analysis questions 2-5. 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 being used? For example, if they normally 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?
    a. Once students have chosen an appliance, have them write it in the box under "Reduce Use" **or** "Unplug When Not in Use." Note that students will be using only ONE of these tables (Reduce Use **or** Unplug When Not in Use) and the wattage value they use in the fourth row is different depending on which box they are using.
    b. Have students fill in the number of hours per day they could reduce the use of the appliance (or unplug it) in the second blank.
    c. Ask students to fill in the third row, indicating how many days per week they could do their chosen action.
    d. Ask students to fill in the number of watts from their energy audit for the appliance they're considering.
        i. Remind them to enter the data on watts used when ON if they chose to reduce use of an appliance.
        ii. Remind them to enter the data on watts used when OFF if they chose to unplug an appliance when not in use.
    e. Have students transfer the numbers from whichever box they chose (reduce use or unplug when not in use) into the equation in analysis question 3.
    f. Have students multiply the four numbers to calculate watt hours/year.
    g. Students will then take their watt hours/year and divide it by 1000 to convert the answer to kWh/year for question 4.
    h. For analysis question 5, they will multiply their kWh/year by 0.75 to calculate how many kilograms of $CO_2$ they could keep out of the atmosphere every year by doing their chosen action. 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 0.75 kg of carbon dioxide.
    i. Tell students to raise their hands once they have calculated their potential amount of conserved $CO_2$ and write every student's value in the class data on the board. Alternatively, students can come up to the board and record their value in the table. Instruct students to copy these data into the class data table on their handout.
    j. Calculate the total carbon dioxide (in kilograms) that could be kept out of the atmosphere from our class alone, and enter this number at the bottom of the class data table.
    k. Direct students to answer analysis question 7 on the handout.
    l. For analysis question 8, students will calculate how much potential $CO_2$ could be conserved by all students in their grade in New Mexico (or whatever classification of students you decided to use – see Preparation note 4 above).
    m. Have students answer analysis questions 9 and 10.
4. Based on this activity, brainstorm with students about two possible action projects the class could do as New Mexico Climate Champions.