Lesson 7: Watt's in a Name(plate)?

Overview

In this lesson, students determine how much electricity a particular device uses by reading electric nameplates and using Kill A Watt meters that monitor electrical energy consumption. They discuss the cumulative effects of parasitic or phantom loads and strategies to minimize and/or eliminate them.

Teacher Background

Appliances and devices use electrical energy by transforming it into other forms of energy. People believe that when an appliance is plugged in but turned off it isn't using energy. This is not true! Many household appliances use small amounts of energy in "stand by mode" even when turned "off." TVs, DVD's, coffee makers, telephones, computers, printers, and a number of other gadgets constantly draw electrical energy as they "wait" to be used. This constant electrical use is referred to as "parasitic" or "phantom" load. Devices such as TVs and DVD players consume as much as 10-15 watts powering built-in remote control functions and digital clocks. AC power adapters and battery chargers also consume standby power even when they are not charging appliances. While this may not seem like a lot of energy, collectively this draw of "on demand" electricity adds up.

Measuring the amount of electricity that different appliances use can seem challenging because 1) we cannot "see" electricity as it is being used and 2) although we may be familiar with terms such as watt, volt, and amp, we are not clear on what they mean in terms of measuring electrical energy. If we consider how electricity travels, how it is measured may become clearer.

Current electricity is produced by electrons on the move. Current electricity requires an unbroken pathway or closed loop (a complete circuit) to flow and undergo transformations. Without a complete pathway electrons cannot flow and electrical devices do not work. Electrical devices house the components of (simple) circuits.

In order to make electrons move, an energy source is needed. Batteries and electricity from a power plant (generator) are most typically the energy sources for household electrical devices. The source pushes electrons through a particular device with a certain

amount of force. The pressure applied to electrons to make them move through a device is known as voltage (V) and its strength is measured in volts (V). A 12-volt energy source (such as a car battery) would apply greater pressure than a 1.5-volt AA battery. In the United States, standard household voltage is 120-volts and certain household devices such as electric ovens and clothes dryers are wired for 240-volts.

The rate at which electrons flow is another aspect of electricity that can be measured. The number of electrons flowing between two fixed points (electrical current) is measured in amps or amperes (A). One amp is 6.25 x 1018 electrons per second passing through a circuit. Electricity can flow through wires with wider diameters faster than wires with smaller diameters. A related property, resistance (R), is one that slows down the flow of electrons. Resistance in electrical devices is anything that slows down the flow of electrons (material that the wire is made of, diameter of the wire, etc.) and is measured in ohms (Ω). Devices called resistors can be placed in circuits to regulate the flow of current.

Watts (W) are used to measure electrical power. Electrical power is defined as the amount of electric current flowing due to a given voltage being applied. Electrical power can also be thought of as the amount of electricity required to start or operate an electrical device for one second. Electrical power can be calculated using the following formula:

$$\text{Power} = \text{voltage} \times \text{current}$$

$$W = V \times A$$

Monthly electricity bills list the number of kilowatts (1000W = 1kW) residents have used and charges homeowners a certain amount of money using the utility company's kilowatt hour rate (in Maine this ranges from 8¢ to 12¢ per kWh). Small appliances (hair dryers, radios, and toasters) and other electrical devices such as incandescent light bulbs are rated by watts.

To operate properly, appliances and other devices need to receive the right amount of electrical energy. If they receive too little energy, the appliance will not operate properly; too much, and the appliance may burn out. Most appliances have the information about its electricity requirements stamped directly on the bottom or back of the appliance or engraved on its electrical nameplate. The wattage listed is the maximum power drawn by the appliance. Many appliances have a range of settings (for example, the volume on a radio) so the actual amount of power consumed depends on the setting. Other appliances, such as refrigerators and electric heaters, cycle on and off so the amount of energy used is based on an average.

In this lesson, students will use an appliance's electrical nameplate to find the number of watts a device uses and then use a Kill A Watt meter to measure its actual use. While it is not expected that students comprehensively understand the different aspects of electrical energy measurement, they will encounter values for amps, volts, and watts and may have questions about their meanings. Use students' background knowledge of electricity as a guide for how much information is provided about these measurements. Because consumers are charged for their electricity use based on the number of kilowatt hours used, watts are the units chosen for comparison. For those that would like additional information on how electricity is measured, review pages 39-41 of the National Energy Education Development (NEED) Project's Intermediate Energy Information book. This resource can be viewed or downloaded at www.need.org.

Be certain to become familiar with how to use the Kill A Watt meter. Included in this lesson is Teacher Resource 7.1: Using A Kill A Watt meter. This handout, from the Maine Energy Education Program (MEEP) www.meepnews.org, provides operation tips and offers additional suggestions as to how to use the meter in the classroom. There are also a number of online videos that show how Kill A Watt meters work and can be used. A couple are suggested in the Preparation section of this lesson and can be found on the PowerSleuth website (www.powersleuth.org).

Key Ideas

- Many devices have parasitic or phantom loads even when switched "off."
- Parasitic or phantom loads cumulatively have a significant impact on overall energy consumption.
- Connecting devices that have parasitic/phantom loads to power strips and turning the strip completely off when a device is not in use and purchasing Energy Star certified appliances are two strategies that can be used to reduce energy use.

Lesson Goals

Students will:

- be able to determine the number of Watts an electrical device uses by reading the device's electric nameplate.
- give an example of a parasitic or phantom load.
- describe the cumulative effects of parasitic or phantom loads.
- suggest strategies to eliminate or minimize parasitic or phantom loads.

Vocabulary

parasitic or phantom load: electricity used by a device even when the appliance is turned "off."

Watt: a unit of power used to measure electricity.

Preparation

- Obtain a set of Kill A Watt meters from your school's library. A set of four meters was mailed (November 2009) to all middle and high school libraries in Maine. Kill A Watt meters are also available at Maine public libraries and can be checked out free of charge. The Maine Energy Education Program (MEEP) may also have additional meters available for classroom use.
- Become familiar with operating the Kill A Watt meters. Tips for using the meter are included in Teacher Resource 7.1: Using the Kill A Watt meter. The following online video clips provide additional information and tips on using the meters: http://www.youtube.com/watch?v=1l_mo1jwh8Y http://vimeo.com/2924444 (Note: This clip shows Kill A Watt meters that have a "calculate cost" feature built in unlike the ones students will be using.)
- Gather a variety of household electrical devices. Try to find some that have a "stand by" power feature and others that have on/off switches. Utilize electrical devices such as computers, printers, speakers, pencil sharpeners, TVs, VCR/DVD players, radios, digital clocks, desk lamps, and overhead projectors that are readily available in the school to minimize preparation time. Consider including older appliances and their newer version counterparts. Have 3-4 appliances for each student group to test and a set of 2-3 items for the opening demonstration. Be sure to gather items that, when activated, will not burn or otherwise be harmful to students. Alternatively, consider setting up appliances in stations around the room and have student groups move from station to station.
- Locate the electric nameplate on each of the items. If the nameplate does not have Watts listed, make certain that the amps (A) and volts (V) are listed. Students can calculate the Watts (W) using the other two values.
- Make certain students have easy access to an electrical outlet. Use power strips or extension cords, if necessary.

Note: *Consult the school's custodian to make certain that the activation of multiple devices will not overload the school's electrical system and blow a fuse. If uncertain, carry out this investigation as a demonstration.*

Materials

Item	Quantity
Scientist's Notebook	1 per student
Variety of household electric devices Include devices that have a "stand by" power feature and others that have on/off switches. Utilize electrical devices such as computers, printers, speakers, pencil sharpeners, TVs, VCR/DVD players, digital clocks, desk lamps, and overhead projectors that are readily a vailable in the school to minimize preparation time.	3-4 appliances for each student group and one set for the opening demonstration
Hand lens	One for each group
Power strips or extension cords	One power strip for opening demonstration / additional power strips or extension cords, as needed
Kill A Watt meters from the school and/or local public library	4 (one for each group)
Student Handout 7.1: Kill A Watt Challenge	1 per student
Student Handout 7.2: Nameplate Data	1 per student
Student Handout 7.3: Kill A Watt Data	1 per student
Student Handout 7.4 (optional): Calculating Annual Energy Costs	1 per student
Calculator (optional)	1 per student
Teacher Resource 7.1: Using the Kill A Watt meter	1 for teacher review

Safety

Review guidelines for using electrical devices safely.

Connection to *Maine Learning Results (MLR)* and *Benchmarks for Science Literacy (BSL)*:

- All technologies have effects other than those intended by the design, some of which may have been predictable and some not. BSL 3B/M2a (6-8)
- Use statistics to summarize, describe, analyze, and interpret results. MLR B1(6-8) c
- Use a variety of tools and technologies to improve investigations and communications. MLR B1 (6-8) e

Teaching The Lesson

Engage

1 Make predictions about energy use.

Prior to the start of class, gather a coffee maker with a digital clock, TV, radio, and power strip. Place these items in a place visible to all students. Ask students to predict which one of these devices they think uses the most electrical energy and why. Mention that students may want to take into consideration what they know about the energy transfers and transformations that take place in these devices. Have students record their predictions in their scientists' notebooks.

2 Introduce electric nameplates.

Provide each student with a copy of Student Handout 7.1: Electric Nameplates. Explain to students that every device that uses electricity has an electric nameplate on it. The nameplate is usually a sticker, but is sometimes engraved into the device. It has information about where the device was manufactured, whether it has been tested for safety, and how much energy it uses. Show students the location of information on the nameplate of one of the demonstration devices. Include:

- wattage (a unit of power used to measure electricity)
- current (the rate at which electric current flows, measured in amps)
- voltage (the force, measured in volts, with which a source of electric current moves) Note: Students may see VAC, power from an outlet, and VDC, power from a battery.

Point out to students that sometimes the nameplates do not contain these three values but the following mathematical equation can be used to calculate the missing information:

$$\text{Watts (W)} = \text{Amps (A)} \times \text{Volts (V)}.$$

Explain that during this investigation, we will be focusing on how many Watts particular devices use because this value can be used to calculate how much it costs to use a particular device.

Have student volunteers assist in locating and/or calculating the number of Watts, using amps and voltage, each of the demonstration devices uses. Have a few hand lenses available to read nameplates that have small print. Students can compare the nameplate information to their predictions made at the beginning of the lesson. On the board, write the number of Watts, amps, and volts for the different devices on the board. Ask students how many Watts of electricity would be used if these devices were used at the same time. (Add the number of Watts together.)

Students may notice that some household devices, in addition to their nameplate, have an Energy Star sticker. Devices that are most efficient receive this label from the U.S. Environmental Protection Agency.

3 Introduce the idea of phantom loads.

Plug the coffee maker, TV, and radio into the power strip. Show students the Kill A Watt meter and explain that the meter measures and displays the same information found on electric nameplates. For this demonstration plug the Kill A Watt meter into the wall, select the Watt setting, and plug the power strip into the wall. Plug the devices into the power strip. Turn the various devices on one at a time and ask students to notice what happens to the number of Watts. Students should notice that the number of Watts increases and decreases as devices are switched on and off. Click off the power strip. Students should notice that the Kill A Watt meter registers zero Watts. Explain to students that this is because the power strip has a switch that completely shuts off the flow of electricity to all of the devices.

Click the power strip back on. The devices should be on and students will once again notice how many Watts the devices are using collectively. Switch off the radio. Ask students what they notice about the number of Watts the meter shows. (The number of Watts should decrease by the number of Watts listed on the nameplate or calculated for the radio.) Switch off the coffee maker. Ask students what they notice. They may notice that the number of Watts decreases by an amount close to but not exactly equal to the number of Watts listed on the coffee makers' nameplate. Lastly, switch off the TV. Ask students what they notice about the number of Watts being used. They should notice that the number of Watts being used has decreased but that the meter is still showing that electricity is being used. Ask students "What's going on?" (or "Watt's going on?") Are these devices "off?" Why does the Kill A Watt meter still show electricity being used?

Explain to students that one thing nameplates do not tell us is whether the device has what is known as a parasitic or phantom load. Parasitic or phantom load refers to electricity used by a device when it is turned "off." Devices that have parasitic or phantom loads often have built in clocks, glowing lights, or remote controls associated with them. Unless these devices are completely disconnected from their power supplies, they continue to "draw" or use electricity.

Ask students how they could use the Kill A Watt meter to determine whether a device has a parasitic or phantom load. Students may suggest that if the Kill A Watt meter reads wattage when the device is "off" then it has a parasitic or phantom load.

Demonstrate the parasitic/phantom load of the coffee maker and/or the TV by plugging the device into a Kill A Watt meter that is plugged into a wall outlet or power switch and switching it "off." Switch the power strip completely off or unplug the device to emphasize the complete termination of electricity.

Discuss with students the impact of parasitic/phantom loads. Students should begin to recognize the cumulative impact of parasitic/phantom loads used by multiple devices over the course of a year.

Explore

4 Investigate electrical use of various electronic devices and appliances.

Students work in small groups of 4 or 5 to investigate the amount of energy used by different devices. Encourage them to first make a prediction as to which devices use the greatest number of Watts and whether or not the device has a parasitic/phantom load. Students can make predictions and collect their data using Student Handout 7.2: Nameplate Data or develop their own method of keeping track of the information in their scientists' notebooks.

Have students find the number of Watts the different devices use by locating the values on the devices' nameplates. Remind students how to calculate any of the values that are not listed on the nameplate by using the formula. (Write the formula on the board.)

Once students have found the number of Watts using the nameplates, have them test the device to determine if it has a parasitic/phantom load. Remind students how to plug in and operate devices safely. Show students how to plug the Kill A Watt meter into the

power strip. Use of a power strip or extension cord makes testing easier. To test a device, students will plug it into the Kill A Watt meter. Again, students may use Student Handout 7.3: Kill A Watt Data or use their scientists' notebooks to record their data. Explain to students that using the meters to find the actual energy used is similar to using a calculator after they've learned how to add and subtract; the meters are a tool but not the only way to find out if a device has a phantom load.

Note: *Have students complete the nameplate activity before providing the Kill A Watt meters. By doing the nameplate portion separate from the Kill A Watt part, students are more likely to spend more time examining the information on the nameplate and will be less prone to taking shortcuts.*

Circulate among student groups and provide assistance as needed. Ask guiding questions and listen to students' ideas about energy use as they work.

Reflect And Discuss 

5 Conduct a scientists' meeting.

Ask students to share what they learned about the devices they surveyed. Discuss the following:

- *What similarities and differences did you notice about the nameplate data and the Kill A Watt data?*
- *Which devices use the most energy?*
- *What do these devices have in common?* (Relate to energy transfers and transformations that may be occurring in the device. Students often notice that devices that make heat use more energy.)
- *Which devices have parasitic or phantom loads?*
- *What do they have in common? Why might these devices "need" to use energy even when they are turned "off?"* (Relate to energy transfers and transformations that may be occurring in the device.)
- *What cumulative effect do you think parasitic/phantom loads have on overall energy consumption? What strategies can be employed to decrease this effect?*

(Optional) Students can calculate the amount of energy various devices will use in one year using the formulas found on Student Handout 7.4: Calculating Annual Energy Cost.

6 (Optional) Investigate devices at home.

As a follow up homework assignment give students the task of locating the nameplates for the devices identified in their snapshots. Allow students to sign out the Kill A Watt meters on a rotating basis so that each can test various devices in their homes for phantom loads.

Extensions

Students may:

- look up the typical wattages of various household devices and use this information to estimate their overall electricity use. This information can also be used to determine whether to invest in a more energy-efficient appliance. http://www.energysavers.gov/your_home/appliances/index.cfm/mytopic=10040
- find out more about Energy Star appliances: http://www.energystar.gov/
- investigate the connection between the Environmental Protection Agency (EPA) and Energy Star labels. Why do you think the EPA is the "issuer" of Energy Star labels?
- predict which room in their house uses the most energy and then use the meters to check their predictions.

Connections to Maine Agencies

MEEP (Maine Energy Education Program) is a no cost resource for schools and teachers in Maine. MEEP representatives will come to interested schools, free of charge, to guide and support the concepts in this lesson and have programs that supplement concepts in this lesson:

- School Energy Efficiency Investigation: Students use tools to see how their school uses energy and where energy is wasted. Tools include an infrared thermometer, a temperature/humidity datalogger, a light meter, and Kill A Watt meter. Students can then make recommendations on how energy can be conserved in their school. This project can also be combined with the Greenhouse Gas Surveys being offered by Maine DEP. More information can be found on the MEEP website: www.meepnews.org/classroomactivities.

For schools in Aroostook County, a Maine Public Service (MPS) representative will come to interested schools, free of charge, to guide and support concepts developed in this lesson. A description

of programs is available at www.mainepublicservice.com. Click on the education section of this site. To schedule a presentation, contact Nancy Chandler at 207.760.2556 or nchandler@mainepublicservice.com.

Online References and Resources :

Lesson modified from the Maine Energy Education Program (MEEP)'s Kill A Watt Challenge Activity.

Energy Efficiency in the Home by Wyatt Wilcox
http://energyseeds.com/2007/10/11/go-solar-and-kill-a-watt/

National Energy Education Development (NEED) Project's Intermediate Energy Information Book (pages 39-41). The NEED Project, PO Box 10101, Manasas, VA 20108. www.need.org

Macaulay, D. (1988). *The Way Things Work*. London: Dorling Kindersley Limited.