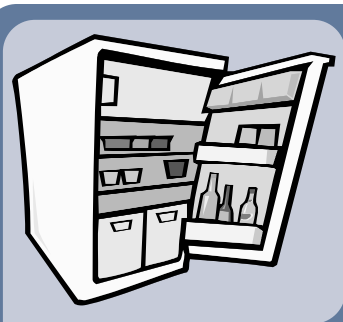

At Watt Rate?

Students complete a survey to determine how much electricity various appliances in their home use.

Grade Level: 5–8 (9–12)

Subject Areas: English Language Arts, Family and Consumer Science, Mathematics, Science, Technology Education

Setting: Classroom, home

Time:
Preparation: One to two hours
Activity: One week

Vocabulary: Ampere, Compact fluorescent light (CFL), Electric current, End use, Incandescent lamp, Kilowatt-hour, Leaking electricity, Lumen, Volt, Watt, Light emitting diode (LED)

Major Concept Areas:

- Energy flow in ecosystems, including human societies
- Consumption of energy resources
- Management of energy resource use
- Quality of life

Objectives

Students will be able to:

- calculate the energy use of various appliances in their home;
- compare the amount of energy used by appliances; and
- analyze their energy use patterns and suggest ways to save energy.

Rationale

By completing electricity end use surveys students become more aware of the amount of energy they use and discover ways that energy can be used more efficiently.

Materials

- Project ***U.S. Residential Sector Electricity Consumption by Major End Uses in 2018***
- Copies of the following pages:
  - ***Daily Energy Use Log***
  - ***Appliance Survey Sheet***
  - ***Parental Permission Form***
  - ***Appliance Survey Background*** (optional)
- Find additional resources related to this activity on keepprogram.org > Curriculum & Resources

Background

Young children's awareness of where energy comes from and how it is used often reflects their everyday and immediate experiences. In their minds, the gasoline for cars simply comes from a service station. The electricity that runs the lights and appliances in homes and schools comes from flipping a switch or plugging an appliance in a wall outlet. The heat used to warm homes and schools is produced by a boiler or furnace that is usually located in the basement of the building. As children get older they are more likely to possess a greater awareness of where energy comes from and how it is used. Gasoline is made from crude oil. Electricity is produced by a power plant and transmitted by power lines. By middle school age, students have a better appreciation for the various energy sources, such as natural gas, fuel oil, electricity, propane, and wood that can be used to heat a home or school. They begin to recognize that our society needs large quantities of energy to keep going.

While we have some understanding about where energy comes from, a greater awareness of how we use energy (energy use patterns) can lead to better ways of managing energy use. We know that our homes use electricity, but we don't know how the electricity required for the lights in the kitchen compares to the amount used by the television in the den.

We use energy for lighting rooms, heating and cooling our homes, heating water, and refrigerating food as well as numerous other activities. Such energy uses can be categorized by devices, products, and systems that use energy for the same or for similar purposes. These categories are called energy end uses.

A typical house in Wisconsin uses several types of energy to power its various end uses. About two-thirds of Wisconsin homes use natural gas for space heating and the rest use fuel oil, liquid propane gas, electricity, or wood. More than half of Wisconsin homes use natural gas for water heating and most of the rest use electricity. Most homes also use electricity for cooling, refrigeration, and lighting.

One way to better understand our energy use patterns is to conduct an end use survey. Conducting energy end use surveys not only increases our awareness of how we use energy in our lives, but also helps us decide how to use energy more efficiently.

Calculating how much energy is used by the electrical appliances and equipment in our homes and schools makes us aware of which ones use large amounts of energy and which ones do not. This can lead us to adopt strategies for using appliances and equipment more efficiently and prompt us to buy new, more efficient appliances and equipment when older ones need to be replaced. Although improving the efficiency of all electrical appliances and equipment saves energy and lowers utility bills, focusing efficiency improvements on those that are large energy users should be the first priority.

Procedure

Orientation

Provide students with copies of the ***Daily Energy Use Log*** to inventory their activities for one day. Encourage students to describe at least one activity per hour. Under the "Item that Uses Energy" column, ask them to identify if they used an appliance or some other item (like an automobile) that uses energy. Under "Source," have them try to identify what energy resource was used (for example, electricity). They should guess if the item uses a lot or a little energy under the "Amount" column.

After students have completed their logs, have them group the items into categories based on whether they use electricity or natural gas or another fuel. Challenge students to organize the list based on which kinds of items use the most energy in their homes.

Steps

1. Tell students that they are going to investigate the electric end uses in their homes. Share the table of ***U.S. Residential Sector Electricity Consumption by Major End Uses in 2018***. Explain that their investigations will focus on the sections labeled "Lighting," "Televisions," and "All Other Appliances.

2. Discuss with students how they could find out more about energy sources and end uses by conducting surveys and how these surveys can help determine if energy is being used efficiently. Have students list reasons why energy efficiency is important. Reasons may include the following:
   - Saves money
   - Helps reduce environmental impacts associated with using energy
   - Can improve comfort and health (such as identifying where drafts come into a house, measuring the temperature of hot water from a water heater to make sure it is not too hot)
   - Conserves nonrenewable energy resources

3. Ask students what they know about the electricity bills their household receives. Help students to understand the bill is for how much electricity they use each month and that their electric meter provides their utility with this information.

4. Discuss how energy use would be measured if an electric meter wasn't available. Students should suggest strategies such as timing how long appliances are left on.

5. Ask how many students have televisions that use electricity 24 hours a day. Most students will think their television is not on this long. Tell students that if their television has a remote control, then their television does actually use electricity all the time. Inform them that this is called leaking electricity. Discuss other forms of leaking electricity (see ***Appliance Survey Background***).

6. Provide students with copies of the ***Appliance Survey Sheet***. Tell students the main piece of information they want to learn from the survey is how many kilowatt hours certain appliances use over a month's time. Essentially, students will be playing the role of an electric meter, measuring the usage of certain appliances. Review the various components of the survey (see ***Appliance Survey Background*** for more information).

   NOTE: This end use survey focuses on frequently used small- and medium-sized electrical appliances, including lighting. The survey is not an exhaustive inventory of energy use at home. Instead, it is designed to help students appreciate the amount of electricity consumed by some of the items they use regularly. See ***Appliance Survey Background*** for more information about the electric end uses that are part of this activity. Review any tips or strategies for taking measurements.

7. Assign students to complete their appliance survey at home. Encourage students to have adult family members assist with the project. NOTE: It is advisable to secure parental permission prior to conducting surveys (see the ***Parental Permission Form***).

Closure

Have students bring their completed surveys to class. Check students' calculations if any of the results varied greatly. Post the results for two or three specific end uses on the board (for example, surveyed items with the calculated kilowatt hours/month for each student; leave out student names to preserve anonymity).

Use survey information to discuss:

- Which surveyed items were used the most? How many hours were these items on each day?
- How does usage vary among students? What might cause some of this variance?
- Are the appliances students use the most also the ones that are most important to them? Explain using two examples.
- Did students list items that they could do without? Discuss reasons why they don't need those items.
- Would students say the items they listed are being used efficiently? Explain using two or more examples.

Have students revisit their ***Daily Energy Use Log***. Can they identify ways that they might reduce their electric consumption? NOTE: It is important that students do not criticize themselves or each other for their daily energy use practices. The goal of this activity is to increase students' awareness of the ways they use electricity. Indeed, students might well note that some of their electric usage—leaking electricity—is difficult to control until manufacturers provide appliances that use less electricity while on standby.

Assessment

Formative

- Did students thoroughly complete the survey and complete the calculations?
- Can students identify the item on their survey that uses the most electricity on a monthly basis?
- How extensively did students analyze their own energy use patterns?

Summative

- Have students create a profile of electric use in their home based on their survey findings. The profile can be a written report, a video documentary, a brochure, or a short story.
- Challenge students to identify the survey findings that indicate that electricity is being wasted or used inefficiently.

Extensions

Students could use the same process to explore electricity use at school. School maintenance staff may need to help students complete school-related surveys, especially if the surveys include lighting.

Students could contact their local utility to find out how much coal, natural gas, or other fuel is required to produce one kilowatt-hour of electricity, for example, and then calculate the emissions associated with converting these fuels into the electricity they use.

Contact your local utility or public library to see if they have a meter that measures the electric usage of appliances. (These meters are often called Watt Meters or Line Loggers.) Watt Meters are available through the KEEP lending program on keepprogram.org > Curriculum and Resources > Hands-on Resources. By plugging the appliance into the meter and then into the socket, students can measure the actual electric use of a particular appliance. Have students revise the survey to incorporate this technology.

Students can practice their letter-writing skills by writing manufacturers with their opinions about leaking electricity.

Students could investigate the other ways that electricity is used in their home. The end use survey captures only a portion of electricity use. More than half the electricity used in a Wisconsin home goes to power major home appliances—refrigerators and freezers, air conditioners, ranges, ovens, dishwashers, etc. The table below details the average U.S. household electric consumption for these items.

Related KEEP Activities

This survey provides an avenue for students to become aware of the different ways they use electricity. A logical follow-up to these surveys is for students to conduct "The Cost of Using Energy" along with the activities "So You Want to Heat Your Home?," "Reading Utility Bills," and "Reading Utility Meters." Students can further analyze their energy use by learning how people in the past might have filled out the surveys. See "Energy Use Then and Now." The Investigation Ideas in the Energy Sparks section provide students with research topics they can use to determine how their lifestyles are influenced by energy use. They can also use these ideas (along with concepts in "Dirty Half Dozen" and "Don't Throw Energy Away") to analyze environmental problems associated with consuming energy resources. Finally, if students want to conserve energy, they can try many of the ideas in Action Ideas: "Energy Efficiency Measures" in the Energy Sparks.

Major Electrical Appliance	Typical Power Consumption (Watts)	Estimated Annual kWh Consumption per Household
Central Air Conditioner	3,000	750 – 1800
Room Air Conditioner	800	250 – 400
Electric Water Heater	4,500	2,200 – 4,700
Refrigerator	400	400 – 500
Dishwasher	1,800	300 – 400
Clothes Washer	425	100 – 400
Clothes Dryer	5,000	600 – 1,200
Freezer	350 - 600	430 – 720
Electric Range / Oven	3,500	240 – 640

Sources: Wisconsin Public Service. Electric Appliance Calculator. Madison Gas and Electric. Appliance Energy Costs. Omaha Public Power District. Appliance Guide.

The Wisconsin K-12 Energy Education Program is supported through funding from

Wisconsin K-12 Energy Education Program (KEEP)
College of Natural Resources
University of Wisconsin-Stevens Point

U.S. Residential Sector Electricity Consumption by Major End Uses in 2018
(as projected in the Annual Energy Outlook 2019)

End use	Billion kWh	Share of total
Space cooling	214	15%
Space heating	207	14%
Water heating	174	12%
Lighting	91	6%
Refrigeration	87	6%
Televisions and related equipment[1]	62	4%
Clothes dryers	60	4%
Computers and related equipment[2]	26	2%
Furnace fans and boiler circulation pumps	25	2%
Freezers	20	1%
Cooking	16	1%
Clothes washers[3]	10	1%
Dishwashers[3]	7	1%
Other uses[4]	460	31%
Total consumption	1,462	

[1] Includes televisions, set-top boxes, home theater systems, DVD players, and video game consoles.
[2] Includes desktop and laptop computers, monitors, and networking equipment.
[3] Does not include water heating.
[4] Includes small electric devices, heating elements, exterior lights, outdoor grills, pool and spa heaters, backup electricity generators, and motors not listed above. Does not include electric vehicle charging.

Source: U.S. Energy Information Administration, Frequently Asked Questions: How is electricity used in U.S. homes?

Daily Energy Use Log

Name ______________________________ **Date** __________________

Activity	Item that Uses Energy	Source of Energy	Amount of Energy

Appliance Survey Sheet

1. Item Name Description of light or appliance	Light in kitchen 4, 60-watt bulbs	Television with remote				
2. Watts # watts used when on	240 watts (4 bulbs x 60 watts)	250 watts				
3. Hours/Day Average # of hours/day "on"	2 hrs/day	4 hrs/day				
4. Is it left on when no one is using it?	Yes	Yes				
5. Does it leak electricity? See **Appliance Survey Background**	No	Yes				
6. Leaking watts (If leaks, estimate of wattage when off—see **Leaking Watts Chart**)	0	4.3 watts				
7. Time item is on in a month Hours/Day (Row 3) x 30 days	60 hrs (2 hrs/day × 30 days)	120 hrs (4 hrs × 30 days)				
8. Time item is not on (30 days x 24 hours) Time item is on (Row 7)	660 hrs (720 hrs - 60 hrs)	600 hrs (720 hrs - 120 hrs)				
9. Watt-Hours used when on Watts (Row 2) x time item is on (Row 7)	14,400 watt-hrs (240 watts × 60 hrs)	30,000 watt-hrs (250 watts × 120 hrs)				
10. Watt-Hours used when off Leaking watts (Row 6) x time item is not on (Row 8)	0 watt-hrs	2,580 watt-hrs (4.3 watts x 600 hrs)				
11. Total Watt-Hours used in a month Watts used when on (Row 9) + Watts used when off (Row 10)	14,400 watt-hrs (14,400 watt-hrs + 0 watt-hrs)	32,580 watt-hrs (30,000 watt-hrs + 2,580 watt-hrs)				
12. Total kilowatt hours for a month Watt-hours (Row 11) divided by 1,000 watts	14.4 kwh/month (14,400 watt-hrs ÷ 1,000 watts)	32.6 kwh/month (32,580 watt-hrs ÷ 1,000 watts)				
13. Rank of item's electricity use (Rank the item using the most electricity #1, the second #2, etc.						
14. Item's relative importance Use a scale of 1 to 5 where 5 = Must have this item; 3 = Item is somewhat important; 1 = Don't need item.						

Appliance Survey Sheet

1. Item Name Description of light or appliance						
2. Watts # watts used when on						
3. Hours/Day Average # of hours/day "on"						
4. Is it left on when no one is using it?						
5. Does it leak electricity? See **Appliance Survey Background**						
6. Leaking watts (If leaks, estimate of wattage when off—see **Leaking Watts Chart**)						
7. Time item is on in a month Hours/Day (Row 3) x 30 days						
8. Time item is not on (30 days x 24 hours) Time item is on (Row 7)						
9. Watt-Hours used when on Watts (Row 2) x time item is on (Row 7)						
10. Watt-Hours used when off Leaking watts (Row 6) x time item is not on (Row 8)						
11. Total Watt-Hours used in a month Watts used when on (Row 9) + Watts used when off (Row 10)						
12. Total kilowatt hours for a month Watt-hours (Row 11) divided by 1,000 watts						
13. Rank of item's electricity use (Rank the item using the most electricity #1, the second #2, etc.						
14. Item's relative importance Use a scale of 1 to 5 where 5 = Must have this item; 3 = Item is somewhat important; 1 = Don't need item.						

Parental Permission Form

Date ______________________________

Dear Parent/Guardian,

Your son / daughter is taking part in a class project where he/she is learning how energy is used in the home. Part of this activity has students collecting information on different energy uses and energy use practices at home. The information will be based on one or more surveys of energy end uses listed below and included with this permission sheet.

Energy End Use Survey(s):

Completing the surveys helps students become aware of the ways energy is used at home. This information may also be used to help students relate home energy use to the cost of energy, and to help them suggest ways energy can be used more efficiently.
Thank you for your cooperation on this project. I (We) will encourage students to share their findings with you.

Sincerely,

____
Teacher

– – – – – – – – – – – – – – – – – – – –

I hereby give my son / daughter permission to conduct a home survey of the energy end uses listed above.

____
Name of Student

____
Signature of Parent/Guardian

____
Date

Appliance Survey Background

Completing the Appliance Survey Sheet

Complete the appliance survey sheet by providing the information and conducting the calculations listed in the first column of the survey. The objective is to calculate kilowatt-hours for one month (row 12). To do this you figure out how long an item is used in one day (row 3) and multiply the total by 30 days (row 7). To be accurate, you also need to consider when electricity is being used even when the appliance is not on (leaking electricity). Rows 5, 6, 8, & 10 help you calculate this figure. There is also information about leaking electricity provided below. The **Appliance Survey Sheet** has sample entries and information on how to do each of the calculations (this is in italics). Following is additional background information you can use to help you complete the survey.

Tips for Measuring Electric Usage

Focus on the items that are used most frequently. Don't measure the lights in closets or appliances that are seldom used. Good candidates for including on the survey are:

- Lights (list each light source in a separate column)
  - in kitchens
  - in family rooms
  - in bedrooms
- Televisions
- DVD players/DVRs
- Video games
- Microwave ovens
- Computers
- Stereo equipment
- Boom boxes
- Cordless phones
- Toaster
- Can opener
- Curling iron
- Blow dryer
- Electric blanket
- Pizza oven

To better estimate the amount of time an appliance is used on a typical day, leave a log book next to the appliance for several days, recording each time the item is turned on or off. This is especially important if different people in the household might turn the item on and off.

Turn off lights before looking for wattage information printed on the light bulb. Make sure that light bulbs have cooled off before removing them to look for wattage information listed on the bulb base.

Appliance Survey Background

Watts: Measuring Electricity Usage

Power and time of use are the two factors that determine how much energy is used by an electrical appliance or piece of equipment. Power is the rate at which energy is used, or work is done, per unit of time. Electrical power is usually measured in watts; hence, electrical power is often referred to as wattage. The higher the wattage, the greater the amount of electrical energy that an electrical appliance or piece of equipment uses over a period of time. For example, a 1,200-watt microwave oven uses twice as much electrical energy and produces twice as much heat in one minute as a 600-watt microwave oven. However, an appliance with a high wattage will not use much energy if it is used for only a few seconds, where as an appliance with a lower wattage may use a lot of energy if it is used for a number of hours. For instance, a 1,200-watt microwave used for only 30 seconds uses less energy than a 600-watt microwave does in one-half hour.

The relationship between the wattage, time of use, and the energy used by an appliance or piece of equipment can be expressed by this formula:

Wattage (Power) × Time = Energy Use

By using this formula, we can compare the energy used by electrical appliances and equipment to see which ones use the most electricity.

Wattage and other electrical information is often listed directly on the appliance or equipment. For example, a label on a microwave oven may look like this:

ACME, Microwave Oven
Model No. X - 15Z
120 Volts AC 5 A 600 Watts 60 HZ
Made in USA

The information on the label tells us that the microwave oven needs 120 volts of electricity in the form of alternating current (AC) to operate, and draws 5 amps (amperes) of current during its use. The 60 HZ number means that the current alternates at a rate of 60 times per second. (See **Volts, Amps, and Watts: What Are They?** for a further explanation of these electrical concepts.) The wattage of the microwave is 600 watts.

If the voltage and current are listed on an appliance but the wattage is not, the wattage can be calculated by multiplying the voltage by the current. Using the information on the microwave oven label, the wattage is equal to:

Voltage × Current = Wattage

120 volts × 5 amps = 600 watts

Wattages for appliances and equipment that do not list wattage, voltage, or current may be found in **Appliance Survey Background** (pg. 17).

If the microwave oven is used an average of half an hour each day, the average amount of energy it uses per day is:

Wattage × Time = Energy Use

600 watts × 0.5 hours per day = 300 watt-hours per day

Appliance Survey Background

Leaking Electricity

Not only do we have more small- and medium-sized electrical appliances than ever before, but many of these appliances never really stop using electricity. If the television has a remote, then part of the TV is always on, waiting for a signal from the remote. If there's a clock on the microwave then the microwave is always using some electricity. Experts call this usage "standby consumption" or "leaking electricity" because people are often not aware that the appliance is using electricity. A single appliance usually leaks only a small amount of electricity each hour (see **Standby Power Supply Table**) but since these appliances leak electricity whenever they are not turned on, and since people have a lot of these appliances, the amount of leaking electricity is significant. The average household spends about $40 a year on leaking electricity. The federal government is working with appliance manufacturers to reduce the amount of electricity that leaks out of new appliances.

Calculating Leaking Watts

If the appliance being measured leaks electricity, you need to add the amount of electricity used when the appliance seems to be turned off to the amount used when the appliance is turned on.

To calculate the amount of electricity an appliance leaks, estimate the number of watts of electricity leaking and multiply this by the number of hours the appliance leaks electricity, just as you did to calculate the amount of electricity used when the appliance is on.

For example, Amy has a television with remote control that uses 250 watts when it is on and leaks 10 watts when it is off. If Amy's TV is on 4 hours every day, then:

4 hours × 250 watts = the amount of electricity used when the TV is on
and
(24 hours – 4 hours) × 10 watts = the amount of electricity used when the TV is off

4 watts × 250 watts = 1,000 watt-hours when the TV is on
(24 – 4) hours × 10 watts = 20 hours × 10 watts = 200 watt-hours when the TV is off

So Amy's TV uses a total of 1,200 watt-hours on a typical day.

Converting Watt-hours to Kilowatt-hours

Because watt-hours are small units, electrical energy is more often measured in kilowatt-hours, where one kilowatt equals 1,000 watts. The energy used by Amy's TV each day in kilowatt-hours is:

$$1{,}200 \text{ watt-hours per day} \times \frac{1 \text{ kilowatt}}{1{,}000 \text{ watts}} = 1.2 \text{ kilowatt-hours per day}$$

Standby Power Supply Table

Type of Appliance	Average (Watts)	Minimum (Watts)	Maximum (Watts)
Air Conditioner	0.9	0.9	0.9
Alarm Clock	1.74	0.99	3.61
Amplifier	0.27	0	1.8
Baby Monitor	1.2	0.7	1.6
Battery Charger	1.4	0.2	3.2
Blue Ray Player	0.46	0.28	0.70
Clock Radio	2.01	0.97	7.6
Coffee maker	1.14	0	2.7
Computer, desktop	2.84	0	9.21
Computer, laptop	8.9	0.47	50
Computer Display LCD	1.13	0.31	3.5
Copier	1.49	0	2.97
Cordless Phone	0.98	0.54	1.8
Digital Cable Box	17.83	13.24	30.6
DVD Player	5.04	0.09	12.7
DVR	36.68	23.3	48.6
Furnace, central	4.21	0	9.8
Game console	1.01	0	2.13
Garage Door Opener	4.48	1.8	7.3
Massager	2.7	1.1	4.2
Microwave Oven	3.08	1.4	4.9
Mini Audio System	8.32	0.3	24.58
Mobile Phone charger	2.24	0.75	4.11
Modem, cable	3.84	1.57	6.62
Modem, DSL	1.37	0.33	2.02
Power Speaker	1.6	0.0	3.1
Power Tool, cordless	1.74	0	4.7
Printer, laser	1.58	0	4.5
Printer, inkjet	1.26	0	4
Range, gas	1.13	0.7	1.7
Receiver	2.92	0	19.7
Security System	2.7	2.7	2.7
Shaver	0.9	0.4	1.4
Surge Protector	1.05	0	6.3
Television, Plasma	.35	0.10	1.0
Television, LCD	1.5	20	0.10
Television, LED	.48	0.0	1.0

Source: Standby Power from Lawrence Berkeley National Laboratories

Appliance Survey Background

Lighting

Enter a dark room. Flip the switch. The lights come on instantly. This simple act may be one of the easiest, most convenient ways modern society uses energy. When people think about how they use electricity, lighting is often what they think of first.

Although lighting does not use as much energy in homes as space heating, water heating, or refrigeration, the amount of energy consumed by lighting cannot be ignored. An average household in the United States spends five to ten percent of its energy budget on lighting. In commercial buildings, including schools, lighting is the second largest energy user after space heating, consuming between 20 and 30 percent of total commercial energy use.

The type of lighting most commonly found in homes is incandescent lighting. An incandescent light bulb contains a filament that glows when it is heated by an electric current. Incandescent bulbs are not efficient; only about five percent of the electrical energy they use is converted into light, while the rest is converted into heat.

Fluorescent lighting is most often used in commercial buildings such as offices, stores and schools. A type of fluorescent light, the compact fluorescent light (CFL), was introduced in the 1980s for use in both residential homes and commercial buildings. These bulbs are 3 to 4 times more efficient than incandescent bulbs. More recently, Light emitting diode (LED) light bulbs have become commercially available and are replacing both incandescent and compact fluorescent light bulbs. Instead of using an electric current to heat thin filaments, LED light bulbs use light emitting diodes made from semiconductor material to produce light that is similar in brightness and color to an incandescent light bulb. Even though they emit the same amount of light, a 12-watt LED light bulb feels cooler than a 60-watt incandescent light bulb. This is because the LED bulb converts more electrical energy into light and less into waste heat. LED light bulbs have efficiencies in the range of 25 percent, making them about five times more efficient than incandescent light bulbs.

Light bulbs are rated in watts, a unit of power. The wattage of a light bulb is a measure of the rate at which it converts electrical energy into light and heat energy. For instance, a 100-watt incandescent light bulb converts electricity into light and heat at a faster rate than a 60-watt incandescent bulb does. Hence, the 100-watt bulb produces more light and heat than a 60-watt bulb does over the same period of time.

This example might suggest that the wattage of a light bulb is the only measure of its brightness or light output. However, a bulb's light output is actually measured in lumens, not in watts. In addition to wattage ratings, all light bulbs are rated in lumens. For example, a 100-watt incandescent bulb produces about 1,710 lumens of light, while a 60-watt incandescent light produces 865 lumens. This example shows that for the same type of light bulb, the higher the wattage, the greater the light output of the bulb. However, this principle does not hold true when comparing different types of light bulbs. For instance, a 20-watt LED light bulb produces about the same amount of light as the 100-watt incandescent bulb, even though it uses only about a quarter of the electrical power, Hence LED bulbs are 4 to 5 times more efficient at producing light than incandescent bulbs.

Vocabulary: Compact fluorescent light (CFL), Fixture, Incandescent bulb, Kilowatt-hour, Light emitting diode (LED), Lumen, Watt

Appliance Survey Background

Small- and Medium-Sized Electrical Appliances and Equipment

Small- and medium-sized electrical appliances and equipment seem to be in every room and classroom in Wisconsin's homes and schools. Televisions and stereo equipment in living rooms deliver news and entertainment. A wide variety of appliances, ranging from electric can openers to microwave ovens, are found in kitchens and help us prepare food. Electric shavers and blow dryers found in bathrooms are used for grooming. SMART Boards, computers, VCRs and DVD players found in classrooms are used to educate students.

Individually, small- and medium-sized electrical appliances and equipment do not use very much energy when compared to other end uses, such as space heating, water heating, and refrigeration. Taken together, however, their energy use is significant. Miscellaneous electricity use in homes, which is made up primarily of small- and medium-sized appliances, equals nearly one-fifth of total electricity use in homes. In addition, greater numbers and more types of appliances and equipment are being used than ever before. The increased use of information technology—computers, printers, fax machines, and photocopiers—in homes, home offices, and schools in recent years is one example.

Volts, Amps, and Watts: What are they?

Introduction

We know that the words volts, amps, and watts are associated with certain electrical concepts. However, we may not know precisely what they refer to. A brief review of the concepts associated with these words follows.

Voltage

All sources of electricity, such as batteries or generators, have the potential to do work (e.g., illuminate light bulbs, run electrical appliances). Potential difference or voltage, describes this potential to do work. The greater the voltage, the more potential the electricity source has for doing work.

The potential to do work should not be confused with actually doing work. For instance, a battery that is sitting on a table but not connected to anything has a voltage, or the potential to do work such as lighting a light bulb. However, the battery will not light the bulb unless it is connected to the bulb in an electric circuit. Only then will the battery actually do work.

The unit of voltage is the volt. One volt is defined as doing one joule (0.74 foot-pounds) of work to move one coulomb (6.25 x 1018 electrons) of charge. Notice that voltage is not defined in terms of work alone, but as work done per a quantity of electric charge. This means that voltage is similar to, but not the same as, work or potential energy. It is convenient to define voltage in this way so that one doesn't have to figure out how many electrons are being moved when work is done on them. This convenience is also helpful when defining electrical power.

Current

Electric current is simply the flow of electrons (or, in some cases, positive charges). In a circuit, current delivers energy from a source of electricity to an electrical device (e.g., a light bulb) or appliance.

The unit of current is the ampere, or amp for short. An ampere is defined as having one coulomb (6.25 x 1018) of electrons flow past a point in an electric circuit every second.

Appliance Survey Background

Volts, Amps, and Watts: What are they?

The Relationship between Voltage and Current

The relationship between voltage and electric current is similar to the relationship between the height of a waterfall and the water that flows down it. A height is needed for the water to flow down the waterfall. The greater the height of the waterfall, the more energy the water has when it reaches the bottom. If no height exists, the water will not flow and it will not have any energy due to motion. Likewise, a voltage is needed to cause an electric current to flow so that it can deliver energy to an electrical device or appliance. The higher the voltage, the more work an electric current can do. If no voltage exists, a current will not flow and work cannot be done.

DC and AC Current

The current produced by sources of electricity comes in two main forms: direct current (DC) and alternating current (AC). Direct current is current that flows in one direction through a circuit. It is produced by sources of electricity whose positive (+) terminal always stays positive and negative (-) terminal always stays negative. For example, a battery produces direct current because the battery's terminals always remain the same; the negative terminal does not change to a positive terminal, and vice versa. Hence, the current will always flow from the negative terminal of the battery toward the positive terminal.

Alternating current is current whose flow in a circuit periodically reverses direction. It is produced by a source of electricity whose positive and negative terminals switch or "alternate" back and forth. In other words, one terminal will switch from positive to negative and back to positive, while the other terminal will switch from negative to positive to negative. Alternating the terminals from positive to negative causes the current to flow in one direction, then in the reverse direction, and back to its original direction, and so on. Electrical generators in power plants throughout the United States produce alternating current that reverses direction 60 times per second. The unit used to describe the rate at which current alternates is the cycle per second, or hertz (HZ).

Electric Power

In general, power is defined as the rate at which work is done, or energy is used, per unit of time. Electric power specifically refers to the rate at which a source of electricity produces energy, or refers to the rate at which an electrical device, appliance, or piece of equipment converts electrical energy into other forms of energy. The faster a source of electricity (such as a generator) produces electrical energy, the greater its power output. The faster an electrical device (such as a light bulb) converts electrical energy into light and heat energy, the greater its power consumption. Electric power is related to voltage and current by the following formula: **Power = Voltage × Current**

The unit of electrical power is the watt. One watt is defined as one volt of potential difference multiplied by one ampere of current.

A watt is also defined as a joule of work done (or energy used) per second. Joules per second are obtained by looking more closely at how voltage and current are defined. Recall that one volt is equal to one joule of work per coulomb of charge, and that one ampere is equal to one coulomb of charge flowing past a point in a circuit per second. Multiplying the two quantities yields:

$$1 \text{ watt} = 1 \text{ volt} \times 1 \text{ ampere}$$

$$= \frac{1 \text{ joule}}{\cancel{\text{coulomb}}} \times \frac{1 \cancel{\text{ coulomb}}}{\text{second}} = \frac{1 \text{ joule}}{\text{second}} = 1 \text{ watt}$$

Notice that coulombs cancel out in the above calculation. This illustrates one reason why it is convenient to define voltage in terms of work and electric charge, rather than in terms of work alone.

Appliance Survey Background

APPLIANCE	WATTAGES (WATTS)
Heating/Cooling	
Dehumidifier	645-785
Fans	
Ceiling	100
20-24” Window	150
Oscillating	88
Portable Humidifier	88
Portable Space Heater	1,500
Office/School Equipment	
Computer	
Desktop (CRT screen)	135
Desktop (LCD Screen)	100
Laptop	20-50
Printer	
Ink Jet	19
Laser	175–275
Photocopier	Up to 2,500
Overhead Projector	1,000
SMART Board	175-300
3-D Printer	40-170
Entertainment	
Fish Aquarium	
Filter	10
Heater	100
Pump	10
Sewing Machine	100
Stereo	60
Television (Color)	
27” Conventional	75-200
42” Plasma Screen	240
42” LCD Screen	150
DVD Player	23
DVR (Digital Video Recorder)	30
Video Game System	160

APPLIANCE	WATTAGES (WATTS)
Kitchen	
Blender	400
Broiler	1,500
Can Opener	120
Coffee Maker (Drip, 2-10 Cup)	900-1,400
Corn Popper	
Hot-Air Type	1,200
Oil-Type	575
Food Chopper	150
Food Processor	360
Frying Pan/Skillet	1,300
Hot Plate	1,100
Kettle	1,500
Microwave Oven	750-1,300
Mixer	
Hand	120
Heavy-Duty	210
Toaster	1,000-1,500
Toaster Oven	1,350
Waffle Maker	1,200
Laundry/Utility	
Iron	1,000
Vacuum Cleaner	650
Personal Care	
Blanket	200
Curling Iron	40
Hair Dryer	1,200-1,500
Heating Pad	50
Shaver	14
Toothbrush (Electric)	7