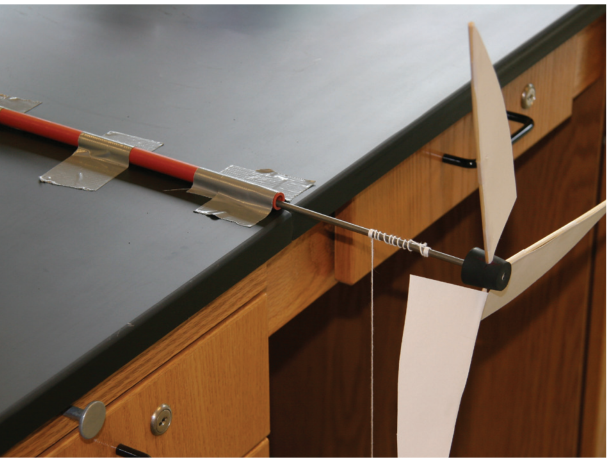
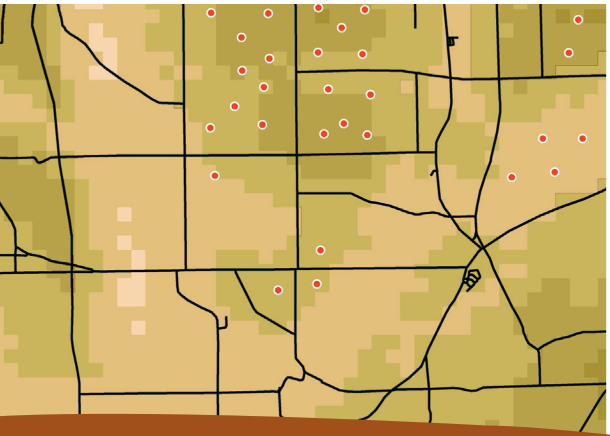
WindWise Education

Transforming the Energy of Wind into Powerful Minds





A Curriculum for Grades 6-12

www.WindWiseEducation.org

NYSERDA

WindWise Education was developed with
funding from the New York State Energy
Research & Development Authority.

V1.0

LESSON 2

WHAT IS THE COST OF INEFFICIENCY?

KEY CONCEPT

Students will learn the difference between energy and power and the role that efficiency plays in reducing energy costs and carbon dioxide emissions.

TIME REQUIRED:

1 – 2 class periods

GRADE LEVEL:

6 – 8
9 – 12

SUBJECTS:

Physical Science
Technology
Mathematics
Environmental Science

BACKGROUND

Energy efficiency and conservation are necessary first steps toward a sustainable energy future. For wind energy to have more impact, we need to use less energy. To make this step happen, all energy users need to understand the value of energy efficiency. This lesson teaches students how to evaluate appliances for energy efficiency, vampire loads, and conservation potential.

OBJECTIVES

At the end of the lesson, students will

- Be able to explain the importance of energy efficiency and how it is different from conservation
- Understand the difference between energy and power
- Know how to calculate the economic savings and CO_2 savings from using efficient appliances

METHOD

Students will test different electrical appliances with a watt meter to demonstrate power and energy. They will calculate the amount of energy that each appliance consumes. Students will then determine how much it costs and the amount of CO_2 produced when each appliance is in use.

MATERIALS

- ❑ Small apple and/or 100 gram weight
- ❑ Meter stick
- ❑ Watt meters (1 per station or student group)
- ❑ Lamp
- ❑ 1 incandescent light bulb and 1 compact fluorescent light (CFL) that produce similar light levels (measured in lumens). For example, a 13 watt CFL typically produces the same light as a 60 watt incandescent.
- ❑ Multiple electrical appliances, including at least 1 that has a vampire load (uses energy even when turned off, such as anything with a remote control or digital clock—a media cart with TV, DVD, VCR, etc. works well), and at least 1 resistance heater (toaster, hair dryer, curling iron, space heater, etc.)
- ❑ Extension cords and/or power strips may be needed depending on how accessible the electrical outlet(s) are in the room
- ❑ Calculator
- ❑ Student Worksheets*

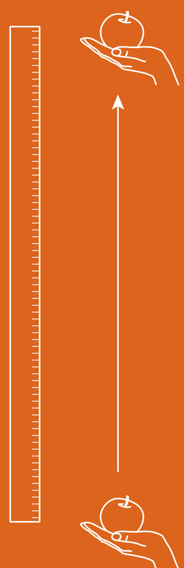
*included with this activity

windwise education

www.WindWiseEducation.org

POWER

$$\text{Power} = \frac{\text{Work}}{\text{Time}} = \frac{\text{Joule}}{\text{Sec}}$$



A Watt is equal to the power needed to lift an apple one meter.

GETTING READY

- Make copies of the worksheet for students.
- Set up electrical appliance stations throughout the room near power outlets. Set up extension cords as necessary to make outlets accessible.
- Distribute Kill-a-Watt meters to each electrical appliance station.

ACTIVITY

Step 1: Beginning Questions for Students

Ask students some questions to get them thinking about using electricity, such as

- What do you use electricity for at home?
- What sources of electricity do you use at home?
- What appliance do you think uses the most electricity in your house? Why?
- What do we use electricity for here at school?
- Why is it important to conserve electricity?

Step 2: Students Predict which Devices are Most Powerful

Show the students a variety of electrical appliances. Have students list the electrical appliances on their worksheets and ask them to rank the appliances by guessing which ones use the most power.

Use a scale of 1 to 10 with 1 being the "most powerful" and 10 being the "least powerful." After they have ranked the devices, see if there is agreement on which appliances will use the most power and which will use the least.

Students will be confused about power and energy. That is OK as we are going to discuss this concept later in the lesson. We are just trying to evaluate what students' preconceived notions are related to energy and power.

Step 3: Discuss Concept of "Power"

Discuss power with the students. Power is the rate at which energy is used.

Ask students to list some other rates (e.g., miles/hour, gallons/minute, hours of television/day, number of tests/year). A rate is typically a quantity divided by an amount of time but can be any ratio between different units.

Explain that electrical power is measured in watts. A watt is a joule/second: Watts = Joules ÷ Seconds; W = j / s (it is expected that students already understand basic energy concepts, such as joules and newtons). A watt is roughly the amount of power needed to raise 100 grams (about the mass of a small apple) one meter of height in one second. Demonstrate one watt by raising one apple one meter in one second, then ask the students if this seems like a large unit of measurement or a small one. Do you have to be "powerful" to lift one apple? Explain to the students that because a watt is a small unit of measurement, kilowatts (kW) and megawatts (MW) are sometimes used. A kilowatt is 1,000 watts, or the power needed to raise 1,000 apples one meter in one second. A megawatt is a million watts. Do you have to be "powerful" to lift one thousand or one million apples?

Step 4: Students Predict which Devices Will Use the Most Energy

Ask the students which of the appliances use the most energy. Use a scale of 1 to 10 with 1 being the "biggest energy user" and 10 being the "smallest energy user." After they have ranked the devices, see if there is agreement on which appliances will use the most energy and which will use the least.

Step 5: Discuss Concept of "Energy"

The amount of energy an appliance uses depends on how much power it needs to operate and, most importantly, how much time it is consuming that power. A very powerful car does not use any gas if it is parked in the garage all day! Energy is the amount of work that is actually done by the appliance. It is a quantity, not a rate. Explain that electrical energy is measured in watt-hours, kilowatt-hours, and megawatt-hours. To find out how much energy an appliance uses, you have to take the amount of watts that it needs to operate and multiply by the length of time that it is on—watts times hours.

Difference Between Energy and Power

	ENERGY Quantity	POWER Rate
Unit	kW-Hour, MW-Hour	Watt, kW, MW
Water Analogy	Gallons	Gal/Min
Car Analogy	How many gallons of gas in the tank?	Engine Horsepower
Cost Example	12 cents/kWh	$1,500/kW
Wind Turbine Application	Electricity produced and sold to the utility company	Rated Capacity of wind turbine

Step 6: Estimate Appliance Usage

Discuss with the class how long each of the electrical appliances might be on in a typical day. Have the students write this on their worksheets. A fraction of an hour may be necessary for some appliances, such as resistance heaters like toasters and hair dryers.

Step 7

Have the students complete the rest of the worksheet. Calculate the cost and carbon dioxide emissions associated with using each appliance.

Step 8: Measure Power Demand of Each Appliance

Demonstrate how to use a watt meter with one of the lamps. Show how the meter can record both power (watts) and energy (Wh). Have the class break up into small groups. Distribute a watt meter to each group. Have the groups measure the power demand of the different appliances spaced throughout the room. Using the worksheet, have the students record the amount of power that the appliances use when they are turned on and when they are turned off but still plugged in.

EXAMPLE POWER LABELS

Model No. SA-EN25
AC~ 120V 16W 60Hz
Made in China

```
Model CLP-315W
Volts: AC 110-127V
Hertz: 50/60 Hz
Amps: 8A
Manufactured
Sept. 2009
```

Watt (W)	Joules / Seconds
kilowatt (kW)	1000 Watts
megawatt (MW)	1,000,000 Watts

Step 9: Wrap Up

Wrap up by discussing what the students discovered. Did they find any vampire loads? Discuss the importance of efficiency for economic and environmental reasons. Discuss the difference between efficiency and conservation. How are they different? Do they overlap?

EXTENSION

- Learn about where your energy comes from by visiting a local power plant.
- Have students conduct a home energy audit. See Worksheet #1 in "Can Wind Power Your Classroom?"
- Create an energy efficiency challenge among classrooms in the school.
- Complete a carbon footprint calculator such as www.wattson.com or coolclimate.berkeley.edu

VOCABULARY

Conservation – Reducing the overall amount of energy you use (i.e. turning off the lights, not just using a more efficient bulb

Efficiency – Ratio of work done to energy spent, typically expressed as a percentage. Using less energy but producing the same benefit. Examples include improved light bulbs or refrigerators

Electrical Load – Anything that uses electricity

Energy – The capacity for doing work; usable power (as heat or electricity); the resources for producing such power

Kilowatt (kW) – One thousand watts. A useful unit of power when discussing household electrical consumption. 1 kW = 1000W

Kilowatt-Hour (kWh) – A unit of energy useful for quantifying household energy use. One kilowatt-hour of energy is equal to the power used at a rate of one kilowatt for a period of one hour

Megawatt (MW) – One million watts or one thousand kilowatts. This unit of power is useful when discussing industrial scale wind turbines or large power plants. 1MW = 1,000kW = 1,000,000W

Megawatt-Hour (MWh) – One million watt hours, a useful measure of energy when discussing large power plants and wind farms. 1MWh = 1000kWh

Power –The rate at which energy changes from one form to another or the rate at which work is done

Vampire Load – Electrical load that uses energy even when it is not in use

Watt (W) – A unit of measure for power, or how fast energy is used. One watt of power is equal to one ampere (a measure of electric current) moving at one volt (a measure of electrical force). One watt is equivalent to one joule of electrical energy per second

Watt-Hour (Wh) – The unit of measurement for electrical energy. 1000Wh = 1kWh

RELATED ACTIVITIES

- Lesson 1: How is Energy Converted to Electricity?
- Lesson 4: Where is it Windy?
- Lesson 5: Can Wind Power Your Classroom?

ADDITIONAL RESOURCES

ENERGY STAR—www.energystar.gov —Energy Star is a "joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy to help people save money and protect the environment through energy efficient products and practices." ENERGY STAR has a wealth of information for anyone interested in reducing energy use. The kids page (www.energystar.gov/kids) is specifically designed to engage youth to learn about energy efficiency.

GET WISE!—www.getwise.org —"The goal of Get Wise! is to help visitors learn ways to conserve water and energy by providing helpful savings tips, links to local resources, and product installation information. Teachers can download classroom materials and find state and federal organizations to enhance the program. Parents and students can find additional information on the program and get questions answered."

EERE (US Department of Energy, Office of Energy Efficiency & Renewable Energy)—www.eere.energy.gov —"EERE works to strengthen the United States' energy security, environmental quality, and economic vitality in public-private partnerships. It supports this goal through: enhancing energy efficiency and productivity; bringing clean, reliable and affordable energy technologies to the marketplace; and making a difference in the everyday lives of Americans by enhancing their energy choices and their quality of life."

EERE KID PAGE—www.eere.energy.gov/kids —"Games, tips, and facts just for kids who want to save energy!"

ALLIANCE TO SAVE ENERGY—www.ase.org —"The Alliance to Save Energy undertakes research, educational programs, and policy advocacy; designs and implements energy-efficiency projects; promotes technology development and deployment; and builds public-private partnerships in the U.S. and other countries." The site has a lot of resources for teachers and students.

NY STATE STANDARDS

Intermediate Level Science–Standard 4: The Physical Setting
Key Idea 4:
Energy exists in many forms and when these forms change, energy is conserved.

Major Understandings:

4.1a The Sun is a major source of energy for Earth. Other sources of energy include nuclear and geothermal energy.

4.1b Fossil fuels contain stored solar energy and are considered nonrenewable resources. They are a major source of energy in the United States. Solar energy, wind, moving water, and biomass are some examples of renewable energy resources.

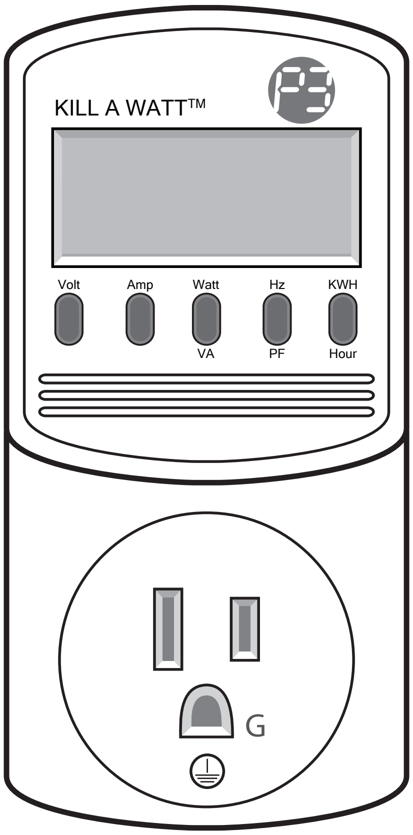
4.1c Most activities in everyday life involve one form of energy being transformed into another. For example, the chemical energy in gasoline is transformed into mechanical energy in an automobile engine. Energy, in the form of heat, is almost always one of the products of energy transformations.

4.1d Different forms of energy include heat, light, electrical, mechanical, sound, nuclear, and chemical. Energy is transformed in many ways.

4.1e Energy can be considered to be either kinetic energy, which is the energy of motion, or potential energy, which depends on relative position.

KILL A WATT METER

The Kill A Watt meter is a device that lets you "see" how much power and/or energy an appliance in your house is using instantaneously or over a period of time. This page will help you understand some of the basic tools on this energy meter.



Volt Button
When the Kill A Watt is plugged into your wall this will probably read somewhere around 120V. When you plug an appliance into the meter it indicates the output voltage required to run your appliance.

Amp Button
The AMP button will measure the flow of electric charge required to run your appliance. This value can vary greatly depending on the appliance you have plugged into the meter. When nothing is plugged in, it should read zero since no charge is flowing.

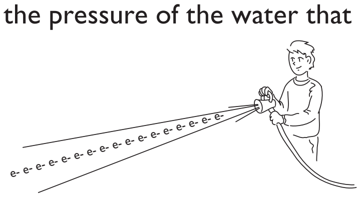
Watt Button
The WATT button measures the power required to run your appliance. This is a measure of the movement of electrical energy required to make your device function (blender, TV, etc.).

KWH
The KWH button measures the amount of energy used by your appliance.

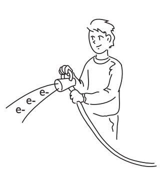
In our water analogy this would be equivalent to a bucket of water. It is a quantity of energy that can do a certain amount of work. If we had a lot of pressure (voltage) and a lot of water (current) moving through a hose we could fill up the bucket very fast.

What is voltage?
A negative charge will attract a positive charge, invisible fields of voltage exist between the charges—kind of like magnetic fields. Voltage causes the attraction between opposite charges, we can quantify this attraction with a simple multimeter.

Using water as an analogy we can also think of voltage like water pressure. Low voltage would be water under low pressure. High voltage would be water under high pressure. The amount of water is not so important—it is the pressure of the water that matters.



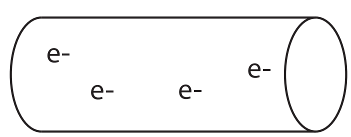
More voltage



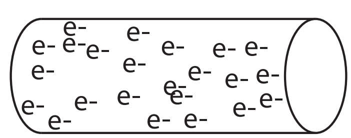
Less voltage

What is current?
Current is the flow of electric charge in a conductor.

Using water as an analogy we can think of this as the amount of water flowing in a tube. The higher the current the more water that is moving in the tube. Low current would be similar to less water flowing in the same size tube.



Less Current



More Current

SAMPLE ELECTRIC BILL

Electric Company Name
Company Address
1-800-555-5555

Service At:
Consumer Name
Consumer Address

Customer Account Number 00000000000	
Due Date Mar 20, 2010	Pay This Amount $43.26
Amount Due After Mar 20, 2010 $52.75	

PREVIOUS CHARGES:

	Account Balance		Amount Due	
Total Amount Due at Last Billing:	$	55.01		
Payment 2/17/10 - Thank You		55.01		
Previous Balance	$	.00	$	.00

CURRENT CHARGES

Customer Charge	$	4.75		4.75
Delivery Charge	$	12.80		12.80
Transition Charge	$	.31		.31
Transmission Charge	$	2.31		2.31
Generation Related Component	$	23.09		23.09
Total Current Charges	$	43.26	$	43.26

READING PASSAGE

Energy is the ability to do work. It comes in a variety of forms, like sunlight, gasoline, electricity, and the food we eat. Each form of energy is useful for doing different things. The most versatile form of energy is electricity. Electricity can be used to do all kinds of work. We can make things move, create sound, generate light, and produce heat. Electricity can be used to do almost anything, from toasting bread to powering supercomputers. There are even electric cars.

Electricity is created in a power plant. It then travels, like water in a pipe, through power lines to get to your house. Most power plants burn some kind of fuel, like coal, oil, or natural gas. Other power plants use renewable energy sources like sunlight, wind, and water. Electricity is expensive to use because the power plants and power lines are expensive to build and the fuel that they burn is also expensive to buy. Saving energy saves money. Using less energy also means that fewer power plants need to be built and less pollution is created by burning fossil fuels.

CAREER PROFILE: JIM BROWN, ENERGY AUDITOR

I help people save money and protect the environment by showing them ways to save energy in their home or work. As an energy auditor, I examine how energy is being used in a building and then make energy efficiency and conservation recommendations to the people who live or work in the building. I might suggest that they buy new, more energy efficient appliances and equipment to replace older, less efficient models. There are also lots of different conservation strategies that I tell people about.

One of the most common things that I will do in any building is to switch all of the inefficient light bulbs to compact fluorescents or other highly efficient lighting technologies. Another lighting technology that I really like is passive solar technologies that allow the use of daylight, which means letting sunlight into the building instead of turning on electric lights. When a building is designed properly there often is little need for lights when the sun is out.

When I perform an energy audit, I use specialized tools, such as watt meters, blower doors, air flow meters, and infrared cameras to evaluate how much energy a building is using. Watt meters measure how much electricity an appliance uses when it is on. They are also really helpful in finding vampire loads—appliances that use energy even when they are turned off. My favorite tool is a blower door, which is used to depressurize a building. By forcing air out of the building with the blower door, I can then find where air is leaking into or out of a building. Air leaks can account for a large percentage of energy use for heating and cooling a building. Infrared cameras can help me pinpoint exactly where the leaks are so that I can come up with a plan to fix them.

Energy auditing is a fun job that involves science, technology, and a good deal of problem solving. The most rewarding parts of the job are knowing that I'm doing something good for the environment and helping people save money. Growing concerns about climate change, energy security, and fuel prices mean that there's more and more work for energy auditors. It's a good career to think about going into.

Name_______________________ Date_____________ Class________

WINDWISE ENERGY EFFICIENCY ACTIVITY WORKSHEET

Electrical Appliance	Predict: which is Most Powerful?	Predict: which uses the Most Energy?	Label power use (W)	Measure power use (W)	Amount of Time Appliance is On Per Day	Amount of Time Appliance is Off Per Day	Energy Appliance Uses in One Day (Wh)	Energy Appliance Uses in One Year (kWh)	Cost to Run Appliance for One Year at $0.17 / kWh	CO_2 Produced in One Year at 0.9 lb. / kWh
Example: (Radio)			40W	36W	2 hours	22 hours	80 Wh **W x Hrs**	50.37 kWh **365 x Wh**	$8.56 **kWh x Rate**	45.3 lb. **kWh x .9**

WINDWISE ENERGY EFFICIENCY ACTIVITY WORKSHEET

Name____ Date________________ Class_________

1. Define power (use examples)

2. Define energy (use examples)

3. Unit Conversions (Remember, 1 kW=100W and 1 MW=1,000,000 W)
   a. 1500 W = _________ kW
   b. 500 kW = _________W
   c. 1000 kW = _________ MW

Using data from the worksheet:

4. Which appliance uses the most power?

5. Which appliance will use the most energy?

6. Why does the appliance that uses the most power not also use the most energy?

7. Name one appliance that would be called a vampire load. Why is it using energy even when it seems to be turned off?

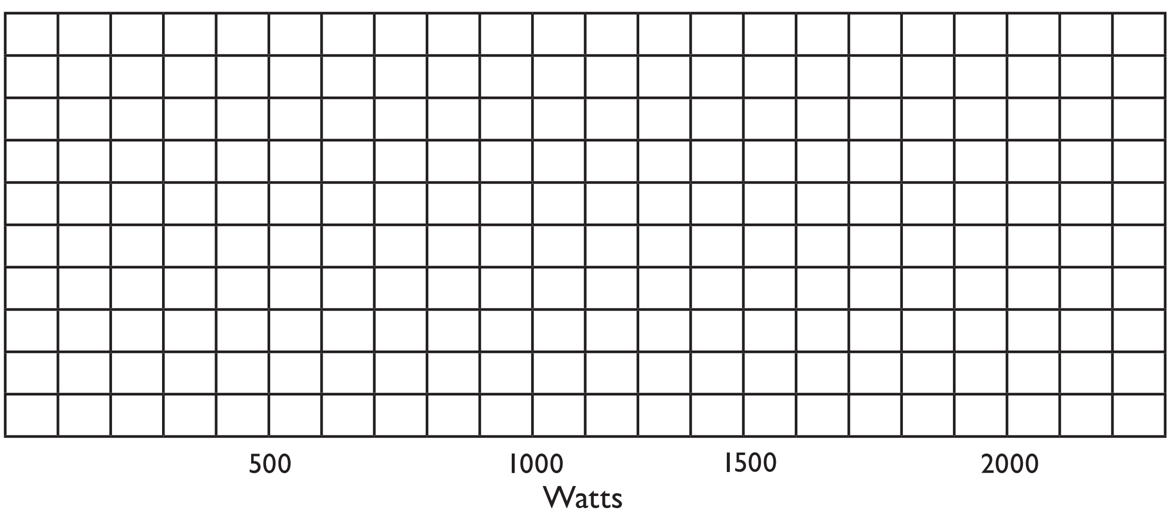
8. How much energy would the following devices use?
   a. 15 watt compact fluorescent that is on for 10 hours ____________Wh
   b. 60 watt incandescent bulb that is on 5 hours ________Wh
   c. 1200 watt oven that is used for 1.5 hours ________Wh

9. Which uses more energy in one month (30 days)?
   a. Vampire load that uses 5 watts for 24 hours a day
   b. 100 watt stereo that is used for 1 hour each day
   c. 1000 watt toaster that is used for 0.1 hour each day

10. Create a line graph of the power use of the different appliances.

Appliance

____
____
____
____
____
____
____
____
____
____



Name______________________________ Date_____________ Class________

11. Create a graph of the predicted energy use of the different appliances.

Appliance

____
____
____
____
____
____
____
____
____
____

Watt-hours

12. What is one way you can save energy at home through conservation?

13. What is one way you can save energy at home through efficiency?

14. Answer the following questions based on the graph below.
    a. People from what country use the most energy per year?

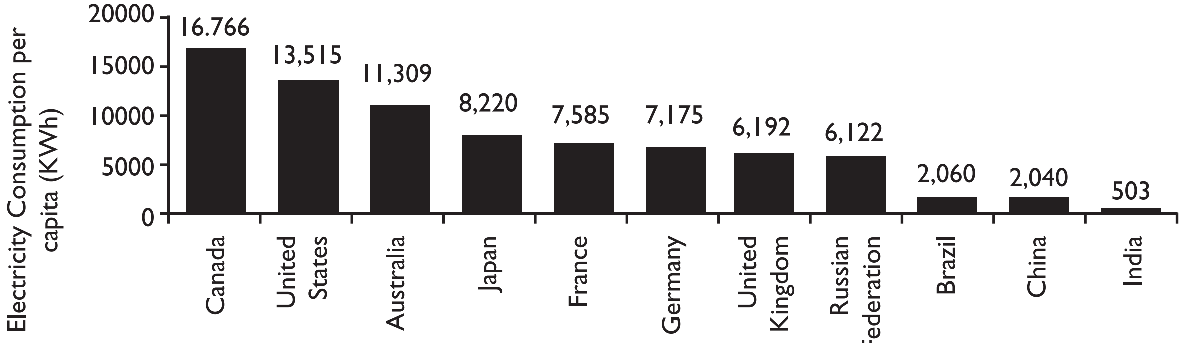
    b. People from what country use the least energy per year?

    c. Why might there be such great differences in energy use among different countries?

d. Do you think that people in Europe (France, Germany, and the United Kingdom) have a lower standard of living than people in the United States and Canada? Why?

e. How many people from India could live their daily lives using the energy consumed by one person from the United States.

PER CAPITA ELECTRICITY USE, AROUND THE WORLD



(Data Source: IEA, Key World Energy Statistics 2008)

1. Define power (use examples)
   Use definition from lesson.

2. Define energy (use examples)
   Use definition from lesson.

3. Unit Conversions (Remember, 1 kW=100 W and 1 MW=1,000,000 W)
   a. 1500 W = 1.5 kW
   b. 500 kW = 500,000 W
   c. 1000 kW = 1 MW

Using data from the worksheet:

4. Which appliance uses the most power?
   Student observations, more than likely this will be refrigerators, air conditioners, toasters, heaters.

5. Which appliance will use the most energy?
   Student observations. Responses will probably be the items that use the most power, as students do not understand the difference between energy and power.

6. Why does the appliance that uses the most power not also use the most energy?
   Energy is the measurement of power use over a period of time. To be the appliance that uses the most energy it will typically use a moderate amount of power a majority of the time.

7. Name one appliance that would be called a vampire load. Why is it using energy even when it seems to be turned off?
   Student observations. Any device that is consuming power when it is turned "off" can be called a vampire load. It may be using energy to stay warm so that it can turn on quickly or is not designed to use electricity efficiently. A few examples include: cell phone chargers, VCRs and DVD players, TVs.

8. How much energy would the following devices use?
   a. 15 watt compact fluorescent that is on for 10 hours 150 Wh
   b. 60 watt incandescent bulb that is on for 5 hours 300 Wh
   c. 1200 watt oven that is used for 1.5 hours 1800 Wh

9. Which uses more energy in one month (30 days)?
   a. Vampire load that uses 5 watts for 24 hours a day 3600 Wh
   b. 100 watt stereo that is used for 1 hour each day 3000 Wh
   c. 1000 watt toaster that is used for 0.1 hour each day 3000 Wh

10. Create a line graph of the power use of the different appliances.
    Student observations

11. Create a graph of the predicted energy use of the different appliances.
    Student observations

12. What is one way you can save energy at home through conservation?
    Turning off lights when you are out of the room
    Take shorter showers
    Energy conservation is changing your behavior in order to save energy.

13. What is one way you can save energy at home through efficiency?
    Using CFL bulbs
    Lowering your thermostat
    Using cold water to wash your clothes
    Using Energy Star appliances

    Energy efficiency is doing the same task using less energy to get the job done.

14. Answer the following questions based on the graph below.
    a. People from what country use the most energy per year?
    Canada

    b. People from what country use the least energy per year?
    India

c. Why might there be such great differences in energy use among different countries?
People from affluent countries generally have larger houses, more electronic devices, and they tend to consume more energy. Also people from northern climates tend to use more energy for heating and lighting.

d. Do you think that people in Europe (France, Germany, and the United Kingdom) have a lower standard of living than people in the United States and Canada? Why?
Student observations will vary, but generally people in Europe have lights, heat and all the electricity they need to lead very modern lives. It is all about doing the same with less and improving efficiency. One place to read more about how much energy we could save and still lead very modern lives is at the Rocky Mountain Institute (www.rmi.org/rmi) or American Council for an Energy Efficient Economy (www.aceee.org).

e. How many people from India could live their daily lives using the energy consumed by one person from the United States.
Approximately 26