Personal Energy Consumption

Objectives

1. Calculate energy savings from changing window size or structure.
2. Calculate energy loss from a dripping hot water faucet.

Safety considerations: Care should be taken to unplug electrical appliances when moving or examining them.

Introduction

Except for the small countries of Luxembourg, Bahrain, Qatar, and Oman, North America uses more energy per person than all other parts of the world. This is true because historically we have always had abundant energy in the form of wood, coal, and oil. Because we have had a large supply, there has been less interest in developing ways to use energy more efficiently.

There are several categories of personal energy consumption that we all have some control over: heating and air conditioning, heating water, lighting, transportation, and purchase and use of electrical appliances.

The measurements used in North America to measure quantities of energy are quite diverse. Many kinds of heat measures are commonly given in British Thermal Units (BTUs), whereas electrical energy is usually measured in metric kilowatt-hours. Rather than try to convert all of the different units to the metric equivalent, we will use the standard units used in ordinary commerce.

BTUs in various amounts of fuel
1 gallon of fuel oil: 145,000
1 cubic foot of gas: 1,031
1 kilowatt-hour of electricity: 3,412
1 ton of coal: 25,000,000
1 cord of wood: 20,000,000
1 gallon of gasoline: 125,000

Procedures

In this exercise we will look at a variety of energy uses or misuses and calculate the energy that would be saved by a variety of changes in the way we do things.

Heating and Air Conditioning

One of the major ways that energy leaves or enters buildings is through windows. A single-pane window has an R-value of 0.9. $1/R$ is equal to the number of BTUs that would pass through a 1-square-foot surface in 1 hour if the difference in temperature on opposite sides of the surface is 1° Fahrenheit. Therefore we can calculate heat loss or gain through a window by using the following formula:

$$\text{heat loss/gain in BTU per hour} = \frac{\text{ft}^2 \times \text{difference in temp. } (^\circ\text{F})}{R\text{–value}}$$

Choose a single-pane window in your classroom or home and measure its surface area. Measure the difference in temperature between the inside and the outside of the window. Calculate the rate of heat transfer through the window by using the formula.

What effect would a 5° F decrease in the temperature on the inside of the window have on the rate of heat transfer?

What would happen to the rate of heat transfer if the size of the window were reduced by 50%?

Double-pane windows have an R-value of 1.85. Triple-pane windows have an R-value of 2.8. What would be the effect on the rate of heat transfer if the single-pane window were replaced with double- or triple-pane windows?

Obtain R-value for special low emission glass and calculate heat loss. Record results on data sheet.

Heating Water

Water resists changes in temperatures. In other words, it takes a lot of heat energy to make a small change in the temperature of water. Therefore water heaters are quite expensive to operate. It takes 1 BTU of heat energy to raise the temperature of 1 pound of water 1° Fahrenheit.

1. Turn on a water faucet so that it is leaking at a rate of about one drip per second.
2. Capture this water for a period of fifteen minutes.
3. Weigh the amount of water you have collected (in pounds).
4. Multiply this number by 35,040 to find the amount of water that would be lost in one year.
5. Assume that water entering the water heater enters at 40° F and leaves the heater at 120° F.
6. How many BTUs of heat energy would be lost in one year if the leak were not fixed?

   Number of BTUs/year = pounds of water in 15 min $\times$ 35,040 $\times$ 80 =
7. How many gallons of fuel oil would it take to produce this much heat?
8. Record results on data sheet.

Lighting

Lighting is something that we take for granted. We usually simply flip a switch and it is instantly there. However, what does it cost in energy to provide the light we use and does it make a difference what kind of light we use?

1. In a dark room, hold a light meter exactly 10 feet from a 40-watt incandescent light bulb.
2. Record the reading on the light meter.
3. Similarly measure the amount of light coming from a 40-watt fluorescent light bulb.
4. Since both bulbs have the same wattage, they use the same amount of electrical energy in the production of light. Which of the bulbs is more efficient in providing light?
5. Approximately how much more efficient is this bulb?
6. Record results on data sheet.

Transportation

North Americans look at freedom of movement as a right. We drive and fly more than any other people in the world. In some urban areas trains provide efficient ways to travel about the city. The millions of miles of highways make it easy for us to travel hundreds of miles. Airports are crowded to the point of being dangerous.

1. For one week, keep a log of all the miles you travel by the following methods:
   a. Foot
   b. Bicycle
   c. Automobile
   d. Train or other rapid transit
   e. Plane
   f. Other
2. Approximately what percentage of each of these was done just for fun?
   a. Foot
   b. Bicycle
   c. Automobile
   d. Train or other rapid transit
   e. Plane
   f. Other
3. Record on data sheet.

Electrical Appliances

Electrical appliances are very convenient. They allow us to do things quickly and relieve us of distasteful or tedious tasks. How much energy do you use as a result of such devices? It is important to recognize that the total energy cost of an appliance also includes the energy necessary to manufacture, distribute, and merchandise the item. However, it might be instructive to determine how much energy is consumed by the use of the various electrical appliances we use. You can find the wattage of an electrical appliance on a label on the appliance.

1. Keep a log of all the electrical appliances you use in a one-week period. List the appliance and the number of minutes it was used per week.
2. Record the wattage of the appliance from the label on it.
3. If you know the wattage and the number of minutes it was used you can calculate the number of kilowatt-hours of energy used (see the equation below).

$$\text{kilowatt–hours used} = \frac{\text{(watt rating)(total minutes used/60)}}{1000}$$

4. If one kilowatt-hour is equal to 3,413 BTUs, how does energy consumption by using electrical appliances compare to energy consumption by automobiles or for home heating and cooling?
5. Record results on data sheet.

Name ______________________

Section ______________________

Personal Energy Consumption Data Sheet

Heating and Air Conditioning

Window	Surface area ft^2	Inside Temperature ° F	Outside Temperature ° F	Temperature Difference	R-value	Heat loss/year (BTU)
Single-pane					0.9	
Single-pane inside temperature 5 ° F cooler					0.9	
Single-pane surface area ÷ 2					0.9	
Double-pane					1.85	
Triple-pane					2.8	
Low-emission glass						

Heating Water

Number of pounds of water collected in 15 minutes	Amount of water lost per year	BTUs needed to heat water lost
	× 35,040 =	× 80 =

Gallons of fuel oil needed to heat the water lost: ______________

Lighting

	40-watt incandescent	40-watt fluorescent
Light meter reading		

How much more efficient is the fluorescent bulb? ______________

Transportation

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   c. Automobile
   d. Train or other rapid transit
   e. Plane
   f. Other
2. Approximately what percent of each of these was done just for fun?
   a. on foot
   b. by bicycle
   c. by automobile
   d. by train or other rapid transit
   e. by plane
   f. other

Electrical Appliances

Appliance	Wattage	Minutes used	Kilowatt hours used
Microwave oven			
Electric stove			
Hair dryer			
Stereo system			
Home computer			
Television			
Dishwasher			
Garbage disposal			
Electric shaver			
Space heater			
Electric fan			
Washer			
Electric blanket			
Vacuum			
Dryer .			