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Calculating the Life-Time Cost of Light Bulbs

How a 35¢ Light Bulb Really Costs More than a $15 One!

Overview

In this activity, your students will address two common misconceptions.

The first is that the purchase price of an item reflects its real cost. In reality, people must also consider the ongoing operating costs of an item over its lifetime. These costs include maintenance, fuel, service fees, financing charges, and repair/replacement. Lifetime costing can show that an item that appears to be cheap or even free up-front can be much more expensive in the long run. Cellular telephones represent a familiar example of this concept: companies give them away and recoup their investment by selling the service. In this activity, your students will see that while common incandescent light bulbs cost very little to buy, their lifetime operating costs make them costly in the long run.

The second misconception is that "watts" are a measure of light output. (After all, a 100-watt bulb is brighter than a 60-watt, isn't it?) Actually, watts are a measure of electrical consumption while "lumens" are a measure of light. A nice way to frame the question is this: "When you flip the light switch, is your goal to buy electricity or to buy light?" If your concern is buying electricity, buy according to the wattage; if your goal is buying light, shop for the most lumens that require the least wattage.

This activity compares the real cost of two different kinds of light bulbs, both of which deliver the same amount of light (number of lumens): a common incandescent bulb and a high-efficiency compact fluorescent bulb.

Incandescent bulbs work like a controlled short circuit. A tungsten filament inside the bulb glows white hot. As a result, incandescent bulbs generate a great deal of heat in addition to light. All of the unwanted heat wastes electricity. Fluorescent bulbs, on the other hand, are filled with a gas that glows or "fluoresces" in the presence of electricity. The compact fluorescent bulb is more efficient because it produces very little heat.

Objectives

By doing this activity students will:

- Understand that energy can be transformed from one form to another.
  - Electrical energy can be transformed into heat and light.
  - Different types of lighting devices use different means to transform electrical energy into light.
  - Light bulbs that produce heat as well as light are inefficient and waste energy on unwanted outcomes.
  - The true cost of an appliance (even as simple as a light bulb) must take into account its lifetime operating cost, including energy consumption and replacement costs.

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Time Requirements

20 minutes for opening discussion and review of the math

30 minutes for completing the math worksheet (either in class or at home)

30 minutes for follow-up discussion

Materials

Student worksheet

For Optional Demonstration

Two lamps

100-watt incandescent light bulb

25-watt high-efficiency compact fluorescent light bulb

NOTE: If you use a 100-watt incandescent bulb, use a 25-watt compact fluorescent; for a 75-watt incandescent, use an 18-watt high-efficiency compact fluorescent. Compact fluorescent bulbs generally emit the same light as an incandescent bulb that uses about four times more electricity. Unlike incandescent bulbs, though, fluorescent bulbs need a few minutes to "warm up" and shine at their full brightness.

Procedure

1. Preliminary discussion

A. Open the discussion by asking a leading question: "Which is cheaper, a 35¢ light bulb or a $15 light bulb?"

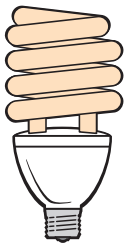
Lead the discussion by asking about all of the costs involved in operating an appliance in addition to the purchase price: operating cost, maintenance cost, cost of financing, replacement cost, and social/environmental costs, just to name the major ones.

B. Ask your students to explain what they know about the word "efficiency" so you can be sure they know what it means.

All work requires energy. When an operation is efficient, completing the work requires less energy than if it were inefficient. A boat with a pointed bow, for example, requires less energy to cut through the water than a boat with a flat bow; it is more efficient. Ask your students to think about examples of efficiency in their own lives, such as techniques they might have for memorizing vocabulary words.

C. Ask your students what they intend to be buying when they flip the light switch. When they answer "light" – duh! – ask if they also realize they are buying heat at the same time. Ask if any of them have ever touched a burning light bulb, and have them describe the experience.

Incandescent
100-watt
1,690 lumens
35¢



Fluorescent
25-watt
1,750 lumens
$15

D. Explain that not all light bulbs get as hot as other bulbs. When a bulb makes just light instead of light and heat, it is more efficient: the electricity is used for the intended work rather than making an unwanted waste product. It does not have to waste electricity to make heat.

The incandescent bulb creates light when electricity runs through the thin tungsten filament inside the bulb. The friction of the electrons running across the thin wire produces intense radiant heat. Part of the electricity goes into making the light, and the rest goes into making the heat. It is "inefficient" because much of the electricity is wasted as unwanted heat instead of light.

The fluorescent bulb, on the other hand, creates light when the electrons excite the gas molecules inside the bulb and cause it to glow, or fluoresce. It is "efficient" because very little of the electrical energy is converted to heat, so the bulb uses less electricity to produce roughly the same amount of light.

2. Math Activity

Have the students complete the worksheet either in class or as homework. Explain that the cost figures vary from store to store. These costs are based on the pricing at a major national chain. Students may work individually, in teams, or with adults at home.

3. Homework

Ask your students to examine the bulbs in their homes and see if they have any fluorescent tubes or compact fluorescent bulb in addition to "halogen" lamps and conventional incandescent bulbs. Also ask them to look for the wattage, the expected life, and the lumens of any replacement bulbs they might have at home.

4. Closing discussion

Lead a discussion about their findings. Their calculations will show that the purchase price does not reflect the true cost of a light bulb at all. Ask what they will think in the future when they see two seemingly similar items in a store with widely different prices and how will they try to analyze the difference.

5. Follow-up

Have your students prepare an advertising and public relations campaign designed to teach people about the relationship between purchase price and true price and to promote the use of efficient lighting equipment.

Extenders

1. Compare the life-cycle cost of a major appliance, such as a refrigerator, washing machine, clothes dryer, dishwasher, or air conditioner. Visit an appliance store to gather information about the costs of efficient and inefficient models. Find out the estimated life expectancy and energy use. Much of this information is located on an Energy Guide Label attached to each new appliance.

Would paying more up front save customers money in the long run?

If so:

- How long would they have to use their appliance to "break even" on the higher price if they bought a more expensive but more efficient model?
- How much money and energy would customers save over the expected life of the appliance?

Discussion Topics

1. Why do energy efficient light bulbs and appliances often cost more than more inefficient models?

   Fewer people buy them, and they cost more to produce and to market. In fact, new technologies often cost more to buy than well-established technologies.

2. In the summer, what is an additional disadvantage of a light bulb that produces unwanted heat?

   Incandescent bulbs generate heat, which increases the strain placed on air conditioners in the hot summer.

Examples of Ways to Conserve Energy

- Buy energy-efficient light bulbs and appliances.
- Turn off light bulbs and other appliances when they are not needed.
- Raise the temperature of air conditioning to 78°F in summer.
- Lower the temperature of heating to 68° in winter.
- Carpool, walk, ride bikes, or take public transportation when possible.

Research Projects

1. **Conduct a "lighting audit" of your home**
   1. How many incandescent light bulbs are in your home?

      ____ # of incandescent bulbs

   2. Estimate the average number of hours per day that each one burns.

      ____ hours per day per bulb

   3. How many kilowatt hours of electricity per day are you using for lighting with incandescent bulbs?

      ____ kilowatt hours

   4. What is the cost of that electricity at $0.16 per kilowatt hour?

      ____ dollars spent on electricity

   5. High-efficiency fluorescent bulbs use about one-fourth the amount of electricity to produce the same light.

How much electricity would you save in one year if you used high-efficiency fluorescent bulbs?

____ kilowatt hours savings with high-efficiency fluorescent bulbs

How much money would you save?

____ dollars savings with high-efficiency compact fluorescent bulbs.

2. **Do a similar "lighting audit" for your school**, asking the maintenance department for help. Figure out how many lighting fixtures use incandescent lights that could be changed to high-efficiency florescent light bulbs. Estimate how long they burn in a typical day and how much replacing them would save in energy and money.

Review

1. What is the difference in the way an incandescent bulb and a florescent bulb produce light?

   An incandescent bulb has a tungsten wire that glows when electricity passes through it and heats it up. A florescent bulb contains a gas that glows when electricity passes through it.

2. What do watts measure?

   Electrical consumption.

3. What do lumens measure?

   Light.

4. Why is an incandescent bulb said to be less efficient than a florescent bulb?

   It uses about 3/4 of its electrical consumption to make heat rather light, yet people use light bulbs for lighting, not heating.

5. What does lifetime costing take into account in addition to purchase price?

   Maintenance, fuel (including electricity), parts (such as batteries), repairs, service fees, expected life span replacement cost.

6. What are some other examples of equipment where on-going operating costs might make an item with a low purchase price more expensive to use.

   Refrigerators, air conditioners, washing machines, clothes dryers, dishwashers, cars.

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Worksheet Name: _____

Calculating the Life-Time Cost of Light Bulbs

NOTE: 1,000 watts burning for one hour equals one kilowatt hour, which is the usual pricing unit for electricity. One kilowatt hour of electricity in New York City costs 16¢.

100-watt Incandescent Bulb (1,690 lumens)

Cost of one bulb	35¢
Life expectancy of one bulb	1,000 hours
# of bulbs needed to burn for 10,000 hours	_____
How much will you pay for all the bulbs you will need to burn for 10,000 hours?	$_____
A 100-watt bulb must burn for how many hours to use one kilowatt of electricity? (1,000 ÷ 100)	_____ hours
How many kilowatt-hours of electricity will you use in 10,000 hours of lighting the bulb? (10,000 ÷ number of hours per kilowatt)	_____ kWh
How much will you spend on electricity in 10,000 hours of operation? (Remember, electricity costs 16¢ per kilowatt hour, so # kWh X $.16)	$_____
If you add together the cost of buying the bulbs and the cost of operating the bulbs, how much will you spend to burn the 100-watt incandescent bulb for 10,000 hours?	$_____

25-watt Compact Fluorescent Bulb (1,750 lumens)

Cost of one bulb	$15
Life expectancy of one bulb	10,000 hours
# of bulbs needed to burn for 10,000 hours	_____
How much will you pay for all the bulbs you will need to burn for 10,000 hours?	$_____
A 25-watt bulb must burn for how many hours to use one kilowatt of electricity? (1,000 ÷ 25)	_____ hours
How many kilowatt-hours of electricity will you use in 10,000 hours of lighting the bulb? (10,000 ÷ number of hours per kilowatt)	_____ kWh
How much will you spend on electricity in 10,000 hours of operation? (Remember, electricity costs 16¢ per kilowatt hour, so # kWh X $.16).	$_____
If you add together the cost of buying the bulbs and the cost of operating the bulbs, how much will you spend to burn the 25-watt fluorescent bulb for 10,000 hours?	$_____

Conclusion

The _____ bulb is $_____ less expensive over its life than the _____ bulb.

Worksheet Answer Key

Calculating the Life-Time Cost of Light Bulbs

NOTE: 1,000 watts burning for one hour equals one kilowatt hour, which is the usual pricing unit for electricity. One kilowatt hour of electricity in Manhattan costs 16¢.

100-watt Incandescent Bulb (1,690 lumens)

Cost of one bulb	35¢
Life expectancy of one bulb	1,000 hours
# of bulbs needed to burn for 10,000 hours	10
How much will you pay for all the bulbs you will need to burn for 10,000 hours?	$3.50
A 100-watt bulb must burn for how many hours to use one kilowatt of electricity? (1,000 ÷ 100)	10 hours
How many kilowatt-hours of electricity will you use in 10,000 hours of lighting the bulb? (10,000 ÷ number of hours per kilowatt)	1,000 kWh
How much will you spend on electricity in 10,000 hours of operation? (Remember, electricity costs 16¢ per kilowatt hour, so # kWh X $.16)	$160
If you add together the cost of buying the bulbs and the cost of operating the bulbs, how much will you spend to burn the 100-watt incandescent bulb for 10,000 hours?	$163.50

25-watt Compact Fluorescent Bulb (1,750 lumens)

Cost of one bulb	$15
Life expectancy of one bulb	10,000 hours
# of bulbs needed to burn for 10,000 hours	1
How much will you pay for all the bulbs you will need to burn for 10,000 hours?	$15
A 25-watt bulb must burn for how many hours to use one kilowatt of electricity? (1,000 ÷ 25)	40 hours
How many kilowatt-hours of electricity will you use in 10,000 hours of lighting the bulb? (10,000 ÷ number of hours per kilowatt)	250 kWh
How much will you spend on electricity in 10,000 hours of operation? (Remember, electricity costs 16¢ per kilowatt hour, so # kWh X $.16).	$40
If you add together the cost of buying the bulbs and the cost of operating the bulbs, how much will you spend to burn the 25-watt fluorescent bulb for 10,000 hours?	$55

Conclusion

The *compact fluorescent* bulb is $*108.50* less expensive over its life than the ____ *incandescent* bulb.