The Cost of Using Energy

Summary:
Students calculate the cost of energy used by various products found in the home and at school.

Objectives

Students will be able to

- calculate the cost of energy used by various products; and
- compare the costs of buying and operating lights and appliances.

Rationale

Calculating energy costs and comparing the costs of buying and operating standard and energy-efficient products enables students to make informed choices when purchasing products that use energy.

Materials

- An incandescent light bulb (optional)
- A 10 to 12-watt LED light bulb with the same or similar light output as the incandescent light bulb (optional)
- Copies of one or more of the following *Life Cycle Cost Comparison Sheets, Student Book,* depending on your classroom needs
  - ***Life Cycle Cost Comparison: Light Bulbs***, page 4
  - ***Life Cycle Cost Comparison: Refrigerators***, page 7
  - ***Life Cycle Cost Comparison: Cars***, page 9

Background

(Also see the Background in "At Watt Rate?," "Reading Utility Bills," and So You Want to Heat Your Home?")

Mr. Jones buys a 60-watt incandescent light bulb for 42 cents. Ms. Smith buys a 10.5-watt LED light bulb that puts out a similar amount of light for $4.00. The incandescent bulb Mr. Jones bought is obviously the better buy, Or is it?

Do we know how much it costs to operate the lights and appliances we have or to fuel the cars we drive? Will buying efficient lighting, appliances, and cars save money in the long run even though they may cost more than their less efficient counterparts?

By answering questions like these, we can find ways to save money and use energy more efficiently.

Determining the cost of the energy we use begins with finding information on energy prices. Gasoline prices are available online (see Resources) or from a nearby service station. Electric and natural gas rates are printed on utility bills. If energy prices are not easily available, average Wisconsin electricity prices for 2017 are included in the Life Cycle Cost Comparison Sheets that accompany this activity.

The next step is to calculate the total cost of energy that products use. A general formula that does this is:

Amount of energy used x energy price per unit of energy = total cost of energy

For example, suppose a car used 10 gallons of gasoline last week. If gasoline cost $2.50 per gallon, then the total cost for the gasoline used is:

10 gallons x $2.50 per gallon = $25.00 per week

This formula can also be used to calculate the total cost of energy used by lights, home appliances, or any other products that use energy. See the Life Cycle Cost Comparison Sheets that accompany this activity for more examples of calculations.

This method of calculating total energy costs can also be used to compare the total energy costs of similar models of products. Comparing items in terms of total energy costs can reveal the model with the lowest total energy costs over time. Choosing this model over others with higher total energy costs would save the buyer money. For example, suppose we compare the cost of fuel per year for two new cars. The purchase cost of the cars is the same, but the first car has an overall fuel efficiency of 25 miles per gallon (mpg) and the second car has an overall fuel efficiency

Grade Level: 5–8 (9-12)

Subject Areas: Family Living and Consumer Education, Language Arts, Mathematics, Science (Physical), Technology Education

Setting: Classroom

Time:

Preparation: 30-45 minutes
Activity: one to three 50-minute periods, depending on how many *Life Cycle Cost Comparison Sheets* are to be completed.

Vocabulary: Life cycle cost, Lumen, LED (Light Emitting Diode) light bulb

Major Concept Areas:

- Quality of life
- Management of energy resource use

Standards Addressed:

Common Core ELA: W.6.7

Common Core Math: MP1, MP4, MP6, MP7; 1.NBT.3, 1.NBT.4, 2.NBT.1, 2.NBT.3, 2.NBT.4, 2.NBT.5, 2.NBT.7, 3.NBT.2, 3.NBT.3, 4.NBT.2, 4.NBT.4, 4.NBT.6, 5.NBT.3, 5.NBT.5, 5.NBT.6, 5.NBT.7, 6.NS.2, 6.NS.3

NGSS: HS-ESS3-3
SEP: Using Mathematics and Computational Thinking
DCI: ESS3.C: Human Impacts on Earth Systems
CCC: Stability and Change

Getting Ready: You may want to gather specific energy cost information from a local utility or a service station.

of 30 mpg. Assume that both cars will be driven an average of 13,000 miles during the year, and the average price of gasoline will be $2.50 per gallon. The fuel costs per year for each car can be calculated using the following formula:

15,000 miles per year X $2.50 per gallon/vehicle mpg = fuel cost per year

The fuel cost per year of the first car is:

15,000 miles per year X $2.50 per gallon/25 mpg = $1,500.00 per year

The fuel cost per year of the second car is:

15,000 miles per year X $2.50 per gallon/30 mpg = $1,250.00 per year

The second car, with an overall fuel efficiency of 30 miles per gallon, has lower fuel costs per year than the first car. Buying the second car would save its owner $250 in fuel costs each year. In addition, fuel cost savings from driving the second car will increase if the price of gasoline increases beyond $2.50 per gallon. Therefore, based on this comparison, the second car is the better buy in terms of fuel costs.

Although choosing products that have lower energy costs is important, it is not the kind of cost information consumers usually look for when deciding which product to buy. Consumers are more likely to compare retail process between product types and will often choose the cheapest one. However, buying a product based only on the lowest retail price may not save money in the long run, because products with the lowest retail price often use more energy and have higher energy costs than similar, more energy-efficient products with higher retail prices. Cheaper, less efficient products may also have shorter useful lives than their more efficient counterparts, so they may need to be replaced more often. For example, an incandescent light bulb may last only 1,000 hours while an LED bulb may last 15,000 hours. Therefore, fifteen incandescent light bulbs would be needed to equal the useful life of one LED bulb.

Accounting for the retail price of a product and the total cost of energy it uses during its useful life is known as calculating the life cycle cost of the product. A simplified formula for calculating the life cycle cost is:

Retail price of product + ([energy cost/year] X [useful life in years]) = life cycle cost

Life cycle cost calculations can show consumers the total amount of money they will have to spend on the product over its useful life. When life cycle costs between products are compared, the one with the lowest life cycle cost turns out to be the better buy in the long run. These products are often the most energy efficient. (see Life Cycle Cost Comparison Sheets to further investigate these calculations.)

A sound understanding of the relationship between energy costs and energy use has many benefits. Knowing how much money we spend on energy to run the products we use can lead to ways of using these products more wisely, thereby saving money as well as energy. Knowing how to compare energy costs of similar products can help us choose products that save energy costs over time. Fortunately, many products that save on energy costs are energy efficient and yield environmental benefits as well.

Procedure

Orientation

Discuss the following scenario with students:

Mr. Jones buys a 60-watt incandescent light bulb for 42 cents. Ms. Smith buys a 10.5-watt LED bulb that puts out nearly the same amount of light for $4.00. Which light is the better buy?

Ask students if they think the cost of electricity used by the bulbs is important, and then ask which consumer will save money in the long run. Record answers on the board or elsewhere so they can be reviewed later. Have students explain the reasons for their answers.

Tell students that they will be learning how to answer questions like these by conducting life cycle cost comparisons for different products.

Steps

1. In the Student Book there are several *Life Cycle Cost Comparison Sheets*. Depending on which *Life Cycle Cost Comparison Sheet* they complete, you may want to review the definition of life cycle costs and sample calculations (see Background; see also examples of calculations found on the sheets).

2. Assign students to one of the three *Life Cycle Cost Comparison Sheets* for light bulbs, refrigerators, and/or cars. You may have the class complete the same sheet or break the class up into three groups and have them complete a sheet for each item. Be sure to review the information found at the beginning of the *Life Cycle Cost Comparison Sheets* with the class so that they understand how to use the information to complete a life cycle cost analysis.

Closure

Have students discuss the answers to the questions on the Life Cycle Cost Comparison Sheets. You may also want to review the scenario discussed in the Orientation and have students revise their answers based on the sheets they completed.

Discuss with students the connection between using energy-efficient products and the cost of using energy. Do students

think that energy efficiency is cost-effective overall? What existing barriers might prevent people from buying more energy-efficient products?

Use the results from the *Life Cycle Cost Comparison Sheets* and the Action Ideas: "Energy Efficiency Measures" from the Energy Sparks section to create an energy management plan.

Assessment

Formative

- How well did students complete the different *Life Cycle Cost Comparison Sheets*?
- Were students able to give reasons why they would buy a particular product based on its energy and life cycle costs?

Summative

Students could perform life cycle cost analyses for products not covered in the *Life Cycle Cost Comparison Sheets*, such as flat screen televisions, water heaters, home heating systems (see Background for life cycle cost information).

Students could also conduct research to see if there are cases where a more energy-efficient product is also cheaper to buy than its standard, less-efficient counterpart, or if there are energy and life cycle cost benefits to buying used versus new items (e.g. cars).

Resources:

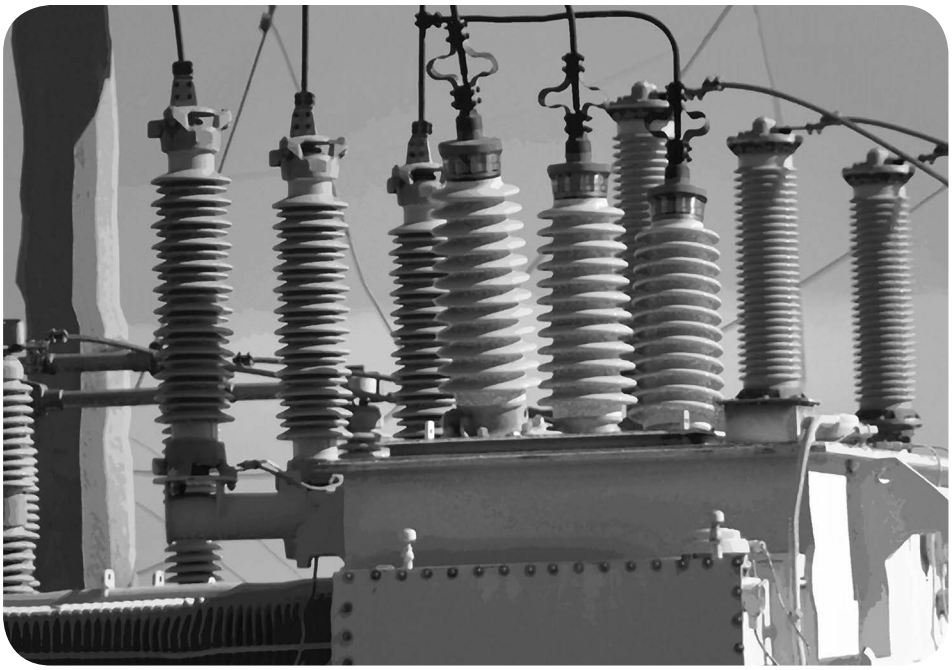
For a list of additional resources related to this activity, visit the KEEP website at keepprogram.org and click on Curriculum & Resources.

See **Resources** in the activity "At Watt Rate?"

American Council for an Energy Efficient Economy (ACEEE). Consumer Guide to Home Energy Savings Online.

Fuel Economy.gov.

Gas Buddy Online



Life Cycle Cost Comparison: Light Bulbs

In this section, you will compare the life cycle costs of using incandescent and LED light bulbs to find out which is the better buy. Answer this question before you complete the rest of this section.

STEPS

1. Suppose you need a new bulb for a fixture that is lit for at least four hours per day. A 60-watt incandescent light bulb costs $0.42. A 10.5-watt LED bulb that provides nearly the same amount of light costs $4.00. Which bulb would you buy and why? Did you take into account the cost of the electricity used to light the bulb over its lifetime in addition to its purchase price?

2. Review the Lighting Information in the table below. You will use this information to calculate and compare the life cycle cost of each bulb.

.Lighting Information

Information Listed on Packaging	Incandescent Bulb	LED Bulb
Light Output	855 Lumens	800 Lumens
Bulb Wattage	60 Watts	10.5 Watts
Bulb Life	1,000 Hours	15,000 Hours
Cost of each bulb (including tax)	$.42	$4.00

Source: Home Depot

3. Divide the bulb life of a LED by the bulb life of an incandescent bulb. Round your answer to the nearest whole number. The answer you get is equal to the number of incandescent bulbs that will need to be replaced to equal the bulb life of one LED bulb. Write your answer in the space below.

4. Use the following formula to determine the total electrical energy used by both bulbs over the bulb life of one LED bulb in kilowatt-hours.

Wattage of bulb (watts) × 1 kilowatt/1,000 watts × bulb life of a LED (hours) = total lifetime electrical energy used by the bulb (kWh)

Incandescent _____ LED _____

5. Write down the electric rate in your area in dollars per kilowatt-hour ($/kWh). If you cannot find out what rate your family or school pays for electricity, use one of the average electric rates listed:

Your electric rate: _____

Home (residential rate): $0.11 per kilowatt-hour (kWh)

School (commercial rate): $0.075 per kilowatt-hour (kWh)

6. Use the following formula to find the total cost of the electricity used by the bulbs over the bulb life of one LED bulb in dollars ($).

Total energy used by bulb (kWh) (Step 4) X Electric rate ($/kWh) (Step 5) = Total cost of electricity used by bulb ($)

Incandescent _____ LED _____

7. Calculate the total cost of purchasing the light bulbs. For the incandescent bulbs, multiply the bulb cost from the *Lighting Information* table by the number of incandescent bulbs needed to equal the life of one LED bulb (see your answer to Step 3).

Cost of one incandescent bulb ($) X Number of incandescent bulbs equal to the life of one LED bulb

Incandescent _____ LED _____

8. Find the life cycle cost (the cost of buying and using the bulbs) of each bulb. Add your answers from Step 6 to your answers from Step 7.

Bulb Type	Incandescent Bulb	LED Bulb
Total Energy Cost ($) (Step 6)		
+ Total Purchase Cost ($) (Step 7)		
= Life Cycle Cost ($)		

Life Cycle Cost Comparison: Refrigerators

Introduction

In this section, you will compare the life cycle costs of two refrigerators (with the freezers on top) to find out which is the better buy.

Steps

1. Suppose you need to buy a new refrigerator. You are considering two refrigerator models: A and B. Both refrigerators have similar features and have the freezer compartments located on top of the refrigerator (top freezer). The model A refrigerator has a lower purchase price but uses more energy than the model B refrigerator. Which refrigerator would you buy and why? Did you take into account the cost of the electricity used by the refrigerator over its lifetime in addition to its purchase price?

2. Review the Refrigerator Information in the table below. You will use this information to calculate and compare the life cycle cost of each refrigerator model.

Refrigerator Data

Refrigerator Model	Refrigerator A (Top Freezer)	Refrigerator B (Top Freezer)
Retail Price (including tax)	$680	$750
Energy used per year (kWh/year)	550	420
Lifetime	15	15

Source: Based on Horie, Yuhta Allan. "Life Cycle Optimization of Household Refrigerator-Freezer Replacement". Report No. CSS04-13. University of Michigan. Center for Sustainable Systems. August 14, 2004.

3. Use the following formula and information from the Refrigerator Information table to determine the total energy used by both refrigerators over their lifetime in kilowatt-hours.

Energy used per year (kWh/year) X Lifetime (years) = Total energy used by refrigerator over its lifetime (kWh)

Refrigerator A _____ Refrigerator B _____

4. Write down the electric rate in your area in dollars per kilowatt-hour ($/kWh). If you cannot find out what rate your family or school pays for electricity, use one of the average electric rates listed:

Your electric rate: _____

Home (residential rate): $0.11 per kilowatt-hour (kWh)

School (commercial rate): $0.075 per kilowatt-hour (kWh)

5. Use the following formula to find the total cost of the electricity used by the refrigerators over their lifetime in dollars ($).

Total electricity used by refrigerator (kWh) (Step 3) X Electric rate ($/kWh) (Step 4) = Total cost of electricity used by refrigerator over its lifetime ($)

Refrigerator A _____ Refrigerator B _____

6. Find the retail cost of purchasing each refrigerator from the Refrigerator Information table, and write the cost in the spaces shown.

Refrigerator A _____ Refrigerator B _____

7. Find the life cycle cost (the cost of buying and using the refrigerators) of each refrigerator model by adding your answers from Step 5 to your answers from Step 6.

Refrigerator Life Cycle Costs

Refrigerator Model	Refrigerator A	Refrigerator B
Total Electricity Cost ($)-Step 5		
+ Purchase Cost ($)-Step 6		
= Life Cycle Cost ($)		

8. Based on the calculations you completed, which refrigerator model (A or B) would you buy and why?

Life Cycle Cost Comparison: Cars

Introduction

In this section, you will compare the life cycle costs of two 4-cylinder sedans with different fuel economies to find out which is the better buy.

1. Suppose you want to buy a new compact and have narrowed down your choices to a Honda Accord and a Toyota Prius, both having similar engine sizes and features. Which car would you buy and why? Did you take into account the cost of the energy used to drive the car over its lifetime in addition to its purchase price?

2. Review the Car Information in the table below. You will use this information to calculate and compare the life cycle cost of each car.

Car Information

Make and Model of Car	Honda Accord 2017	Toyota Prius 2017
Engine and Transmission	2.4 Liter engine, Automatic	1.8 Liter Engine, Automatic
Suggested Retail Price (including tax)	$25,000	$28,000
Miles Driven each Year	15,000	15,000
Lifetime (years)	10	10
Fuel economy (miles per gallon)	30 mpg	52 mpg

3. Use the following formula and information from the Car Information table to determine the total number of miles driven by both cars over their lifetime in miles.

Miles driven per year (miles/year) X Lifetime (years) = Total number of miles driven over car's lifetime (miles)

Honda Accord _____ Toyota Prius _____

4. Use the following formula and information from the Car Information table to determine the total number of gallons of gasoline used by both cars over their lifetime in gallons.

Total number of miles driven over car's lifetime (miles) / fuel economy of car (miles per gallon) = Total number of gallons of gasoline used over car's lifetime (gallons

Honda Accord _____ Toyota Prius _____

5. Write down the cost of gasoline in your area in dollars per gallon ($/gallon). If you do not know the cost of gasoline in your area, use $2.50 per gallon for the cost.

Cost of gasoline: _____

6. Use the following formula to find the total cost of the gasoline used by the cars over their lifetime in dollars ($).

7. Find the retail cost of purchasing each car from the Car Information table, and write the cost in the spaces shown.

Honda Accord _____ Toyota Prius _____

8. Find the life cycle cost (the cost of buying and driving the car) of each car by adding your answers from Step 6 to your answers from Step 7.

Make and Model of Car	Honda Accord 2017	Toyota Prius 2017
Total Gasoline Cost ($)-Step 6		
+ Purchase Cost ($)- Step 7		
= Life Cycle Cost		

9. Based on the calculations you completed, which car (Honda Accord or Toyota Prius) would you buy and why?