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Home Utilities: Saving Money and Environmental Resources

Suggested Grade Levels: 6 and up

Possible Subject Area(s): Consumer Education; Environmental Science; Economics

Math Skills: problem solving using the four operations; calculating percents; writing/using formulas (optional)

Overview: Students will explore typical home energy and water use for various time units (day, month, and year). Usage is viewed in terms of consumed quantities, as well as cost, with students being encouraged to consider conservation of environmental resources in addition to home finances.

Student Activities: Home Utilities: Saving Money and Environmental Resources

I. A fairly recent, significant invention in home lighting technology is the compact fluorescent lamp (CFL). CFL's screw into ordinary light sockets, but they have some important differences in relation to the usual incandescent light bulb. Use the table below to answer the questions that follow.

Incandescent and Compact Fluorescent Light Bulb Comparison

Feature	Incandescent	Compact Fluorescent
Watts consumed	100W	27W
Rated bulb life	750 hours	10,000 hours
Cost per bulb	$0.75	$25.00

Source: *Home Energy Brief*, Rocky Mountain Institute (http://www.greendesign.net/rmi/heb/lighting.htm#Compact%20Fluorescents)

1. By using mental estimation only, tell which bulb you think is a better buy, and why.

2. The CFL lasts for 10,000 hours. How long do you think it would take to "use it up" in days or years?

3. How many bulbs are needed for each type of bulb to last 10,000 hours?

4. "Watts consumed" means the amount of energy used in one hour. A kilowatt (kW) equals one thousand watts (1 kW = 1000 W). How many kilowatt hours (kWh) does each type of bulb consume?

5. If the cost-per-kWh is 8.3¢ (which would be the same for both types), what would the operating cost of each bulb be per 10,000 hours?

6. What is the cost of the actual light bulbs ("lamps") for each type of bulb for 10,000 hours of use?

7. What is the total cost (light bulbs plus operating costs) for each type of bulb for 10,000 hours?

8. Which type of bulb would you buy, and why?

II. In this section, you will explore questions related to energy use of refrigerator/freezers. According to the Rocky Mountain Institute, refrigerators and freezers account for about one-sixth of a home's electricity use.

1. Suppose an 18.2 cubic feet refrigerator with a top freezer uses 591 kWh per year and a 23.6 cubic feet, side-by-side refrigerator/freezer with through-the-door ice uses 799 kWh per year (both have automatic defrost). Clearly, the larger one uses more energy, but which is more energy-efficient for its size?

2. Side-by-side refrigerator/freezers use about 7-13% more energy than top-freezer models of similar size. If a 21.6 cubic feet refrigerator with a top freezer and automatic defrost uses 650 kWh per year, how many kWh/y would a same-sized, side-by-side, automatic-defrost refrigerator/freezer use?

3. Automatic ice-makers increase energy use by about 14-20%. How much energy would the side-by-side refrigerator/freezer from #2 above use if it also had an automatic ice-maker?

4. Manual-defrost freezers consume 35-40% less power than similar automatic-defrost models. About how much energy could the refrigerator/freezer in #3 above (with automatic ice-maker) save if it were manual-defrost?

5. What type of refrigerator/freezer uses the most energy and which uses the least?

III. In this section, you will explore questions related to home water use.

1. A typical toilet uses about 4.5 to 5 gallons of water per flush, and the number of per-person flushes in the home is about 4 to 5. Assume that your toilet use 5 gallons of water per flush and each person flushes 4 times per day. How many gallons of water per month does this amount to for your family?

2. If your water company charges $1.99 per thousand gallons, how much money would you pay for toilet flushes in one month?

3. If you installed a low-flow toilet that uses 1.6 gallons of water per flush, how much money would your family save on your monthly water bill? How much would this be in a year?

4. Faucet water flows at about 2 gallons per minute, and people brush their teeth for about 2 minutes each time they brush. Assume all members of your family let the water run while brushing their teeth and that they brush their teeth twice daily. How much water would they waste monthly by not turning the water off while brushing their teeth?

5. Assume your shower head has a water flow of 4 gallons per minute, and you usually take one 8-minute shower daily. If you shorten the time to 7 minutes, how many gallons of water could you save in a year?

6. One source says the per-capita (per-person) number of daily baths is .1 and the per-capita number of daily showers is .67. What does this say about how often people do one of these (bathe or take a shower) each day?

7. Suppose your faucet had a leak of 1 drip every two seconds. (Five drips per second creates a steady stream.) Go to the WaterWiser Drip Calculator at http://www.waterwiser.org/frameset.cfm?b=2 and determine how much water you would waste in a day, a month, and a year.

Information for the Teacher

Before engaging the light bulb questions in Section I, the teacher might want to establish why 10,000 hours is a useful number of hours for comparing the two types of bulbs. (It is the number of hours one CFL is supposed to last, so it is a good benchmark from which to work.) The teacher might also have students discuss Section I #1 in small groups or pairs, and then discuss students' ideas as a class before they begin their independent work with #2. (This work should be mental only.) Students will explore this question mathematically throughout this section to arrive at a more calculated answer in #8, so answers provided at this point should be explained without evaluation.

For kWh cost used in Section I, the teacher may want to substitute the local rate. Also, it might be helpful to remind students that "kilo" means "thousand" and relate kilowatts to kilograms and kilometers.

CFL's are much more environmentally friendly than incandescent bulbs. The Rocky Mountain Institute's Home Energy Brief on lighting states: "Each incandescent bulb we replace with a CFL prevents the emission of 1,000-2,000 pounds of carbon dioxide from powerplants that leads to global warming, and 8 to 16 pounds of sulfur dioxide that causes acid rain. One CFL also eliminates the need to produce and dispose of up to a dozen incandescent bulbs."

Before students engage the refrigerator/freezer questions in Section II, the teacher might want to discuss the meaning of cubic feet. The teacher might also want to add questions to this sections, or—better yet—have students do so, using the following information: Refrigerator temperature should measure between 36°F and 40°F and the freezer between 0° and 5°. A refrigerator can use 25% more energy at 10°F below the recommended levels. (Note that it is recommended that temperatures be checked with a thermometer.)

The teacher may want to have students use or create formulas where appropriate throughout this module. For example, students might be asked to write a formula for Section I #5. (Some students may also need help expressing 8.3¢ as a decimal in working with this item.) The teacher might also have students work with the following formula: Wattage x Hours Used Per Day ÷ 1000 = Daily Kilowatt-hour (kWh) Consumption (1 kW = 1,000 W). Energy use of selected common home appliances may be found on the U.S. Department of Energy's web site at http://www.eren.doe.gov/consumerinfo/refbriefs/ec7.html.

Figures on which data used in this module are based vary according to different sources. For example, water use for a "typical" toilet flush ranged from 3.5 to 7 gal./min. (low-flow use was much more consistent at about 1.6 gal./min.), and shower head flow ranged from 1.6-10 gal./min. One cause of this variation is the fact that different types of toilets and shower heads yield different water usage, in addition to the variation in figures that is found among different research sources. Most commonly used or middle figures were applied to the questions posed here. Similarly, figures reported for the amount of water used in taking a bath vary widely. Students may want to research this information using the web resources suggested below, and then determine the water use difference between taking a shower and a bath.

The teacher may want to replace the water cost-per-gallon used in this module's Section III with the current local cost. As of July 2002, the cost for a water company in Reno, Nevada, was $1.56 per 1000 gallons for the first 6000 gallons and $2.43 per 1000 gallons for every thousand thereafter. (The cost used for problems in this module was stated as a figure in between, $1.99.)

It is important to emphasize the environmental importance of conserving resources, rather than only cost savings. The cost of excess electricity or water use might not seem like much to students. See, for example, the answers to #'s 2 and 3 in Section III. Also, although #7 in Section III does not pose a question about cost, the two-drip-per-second water loss results in an extra yearly cost of only $3.14 at $1.99 per thousand gallons, but it wastes 1,577 gallons of water.

Answers to Problems and Questions

I. Light Bulb Comparison Problems

1. Answers will vary. (See comments about this item in Information for the Teacher.)

2. Answers will vary based on the number of hours students think the bulb might be turned on daily. If, for example, students think the bulb would be in use an average of 5 hours daily, the bulb would last for 2000 days (10,000 ÷ 5), which is about 5.5 years.

3. Incandescent: about 13 (10,000 ÷ 750 = $13\ ^{1}/_{3}$). CFL: 1 (given).

4. Incandescent: .1 (100 ÷ 1,000). CFL: .027 (27 ÷ 1,000).

5. Incandescent: $83.00. CFL: $22.41. (Take the number of watts consumed times 10,000 hours; divide the result by 1,000 to arrive at kWh; multiply kWh by $.083.)

6. Incandescent: $9.75 for the 13 bulbs needed (some students might say $10.00 because the actual number of bulbs needed is 13 $^{1}/_{3}$). CFL: $25.00 (given).

7. Incandescent: $92.75 ($83 + $9.75), or $93 for students who used $10 in #6. CFL: $47.41 ($22.41 + $25).

8. It is anticipated that students will conclude that CFL's are the better buy over time.

II. Refrigerator/Freezer Problems

1. The refrigerator with top freezer, because it uses 32.5 kWh per cubic foot and the side-by-side uses 33.9 kWh per cubic foot.

2. 695.5 - 734.5 kWh (45.5 - 84.5 kWh more than the top-freezer style).

3. About 793 – 881 kWh (.14 x 695.5 = 97.4; 695.5 + 97.4 = 792.9; .2 x 734.5 = 146.9; 734.5 + 146.9 = 881.4).

4. Answers will vary. One possible answer is 300-330 kWh, which figures 37.5% of the upper and lower limits of the kWh range shown in #3 above.

5. The type that uses the most is a side-by-side with an automatic ice-maker and automatic defrost. The one that uses the least has a top freezer and no automatic ice-maker or automatic defrost.

III. Home Water Use Problems

1. Answers will vary. For a four-person household, the answer would be 80 gal/day (4 people x 4 flushes per day x 5 gallons of water per flush).

2. Answers will vary. For a four-person household in a 30-day month, the answer would be $4.78 (80 x 30 days = 2,400 gal/month; 2,400 ÷ 1,000 gal = 2.4; 2.4 x $1.99 = $4.78).

3. Answers will vary. For a four-person household, the answer would be $3.25 per month, which is $39 per year. (The family would use 25.6 gal/day; 25.6 x 30 days = 768 gal/month; 2,400 ÷ 1,000 gal = .77; 2.4 x $1.99 = $1.53; $4.78 - $1.53 = $3.25.) (Another way to arrive at the $1.53 figure is to determine that 1.6 gallons is 32% of 5 gallons, and then take 32% of the figure for 5 gallons; .32 x $4.78 = $1.53.)

4. Answers will vary. For a four-person household, the answer would be 960 gallons for a 30-day month (4 people x 2 times x 2 gallons x 2 minutes = 32 gallons/day; 32 x 30 days = 960).

5. 1,460 gallons (4 gallons/day x 365 days).

6. It is difficult to say. Students might reason that the combined total for a shower or bath is .77 per capita, which means that 77% of people take one of these daily. However, this cannot be assumed, because some people take more than one shower or bath daily, or at least some days. Students can conclude, however, that not all people take a bath or shower daily.

7. About 4 gallons daily, 130 gallons monthly (30 days), and 1,577 gallons yearly.

Sources and References

Energy Efficiency and Renewable Energy Network, U.S. Department of Energy: http://www.eren.doe.gov/consumerinfo/refbriefs/ec7.html
Home Energy Brief, Rocky Mountain Institute: http://www.greendesign.net/rmi/heb/
Home Water Check Up, University of South Florida: http://www.ficus.usf.edu/docs/water_calculator/calculator.htm
Home Water Use…A Family Survey: http://sjr.state.fl.us/
H_2ouse Water Saver Home: http://www.h2ouse.org/
WaterWiser: http://www.waterwiser.org/

Selected Resources

EnergyIdeas.org: http://www.energyideas.org/
Family Water Use Survey: http://sjr.state.fl.us/ [Publications → General Publications Ordering]
Home Water Check Up, University of South Florida: http://www.ficus.usf.edu/docs/water_calculator/calculator.htm
H_2ouse Water Saver Home: http://www.h2ouse.org/
Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy: http://www.eren.doe.gov/
Rocky Mountain Institute: http://www.rmi.org/
U.S. Environmental Protection Agency: http://www.epa.gov/
Water Science for Schools, U.S. Geological Survey: http://ga.water.usgs.gov/edu/
WaterWiser: http://www.waterwiser.org/ [Books → Water Conservation Tips for Home and WaterWiser Drip Calculator]