Summary: Students conduct lighting surveys to calculate the cost to light their homes and compare that to the cost of lighting their classroom.

Light and Your Load

Grade Level: 9–12 (5–8)

Subject Areas: English Language Arts, Family and Consumer Science, Health, Mathematics, Social Studies

Setting: Classroom

Time:
Preparation: 1 hour
Activity: Two 50-minute periods

Vocabulary: Kilowatt-hour, watt, T-5 or T-8 lamps, electric rate, blended rate

Major Concept Areas:

- Quality of life
- Quality of the environment
- Management of energy resource use

Getting Ready:

Refer to a typical residential electric bill (your own for example) and identify what the current electric rate is for your area.

Contact the facilities manager to request a copy of a typical electric bill for your school.

Calculate the blended electric rate. To do this, use the total cost due for electricity and divide by the total number of kWh used for the billing period found on your school's electric bill. Your blended rate will likely be in the $0.09/kWh - $0.14/kWh range, which will be higher than the on-peak and off-peak electric rates (if your school is charged, and most are) shown on your bill. The blended rate is higher because it takes into account the demand charges and other fees found on

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Objectives

By the end of this activity, students will be able to:

- calculate the cost of lighting the four most frequently used rooms in their house;
- calculate the cost of lighting their classroom;
- evaluate the efficiency of the lighting used both at home and at school;
- identify ways to educate students and staff about the cost of lighting.

Rationale

Calculating lighting costs, both at home and at school, will expose students to the energy expenses associated with today's standard of living. Comparing efficient lighting options will hopefully lead students to make informed choices when purchasing lighting products.

Materials

- Copies of the ***Lighting Comparison Activity Sheet***
- Calculator (optional)

Background

(Also see the **Background** for "Demanding School Electric Bills.")

How would you feel if you had to grade homework by candlelight? How practical would it be to conduct science experiments in a lab without lights?

Lighting is required for nearly everything we do during our waking hours. Natural daylighting can be used for many things, but some artificial lights are needed when natural light is simply unavailable or inadequate.

At home, you may sit next to a window and have enough light to grade homework, but what happens when the sun goes down? Most teachers will flip on the light switch without thinking twice. In general, most people do not think about the energy used to light their homes.

Calculating the energy required to light your home can be done fairly easily. The number of fixtures can be determined by simply looking around each room. Determining the number of light bulbs and their wattage in each fixture may be somewhat more difficult, especially if the lamp(s) are enclosed, however, with a little help and possibly a ladder, you should be able to obtain that information. Once you have the number of lamps and their wattages, you may calculate the kilowatt-hours used by multiplying the number of lamps x wattage x hours used/day and divided by 1000 to convert to kilowatt-hours/day.

$$\frac{2 \text{ lamps} \times 100 \text{ watts/lamp} \times 4 \text{ hours on/day}}{1000 \text{ watts/kilowatt}} = 0.8 \text{ kilowatt-hours (kWh)/day}$$

If no one is home during the week, lights might only be used at night, but used more frequently during the weekends. However, if people are home during the week, lights may be used the same hours each day, weekday or weekend. To calculate the lighting costs for a month, multiply the kWh/day by 30 days. For a more accurate calculation, keep track of the actual hours the lights are on for a month.

Compact fluorescent light bulbs (CFL) last up to ten times longer and use approximately one quarter of the energy that a incandescent light bulb uses to produce the equivalent light output. Light emitting diode bulbs (LED) last twenty-five times longer than incandescent lighting and require less energy than CFLs. Refer to the chart on the next page for a quick comparison of wattage requirements for similar light outputs.

Note: Like all fluorescent lamps, CFLs do contain a small amount of mercury—an average of five milligrams (mg) per bulb. By comparison, some watch batteries contain 25 mg of mercury and many manual thermostats contain up to 3,000 mg.

In many schools, there are classrooms located on interior walls without windows

Incandescent Bulb	Compact Fluorescent Bulb (CFL)	Light Emitting Diode Bulb (LED)	(Minimum) Light Output in Lumens
40 watt	9–13 watt	4-5 watt	450
60 watt	13–15 watt	6-8 watt	800
75 watt	18–25 watt	9-13 watt	1,100
100 watt	23–30 watt	16-20 watt	1,600
150 watt	30–52 watt	29-28 watt	2,600

Approximate Wattages for Fixtures			
	T8 32W 4' fluorescent	T5 28W 4' fluorescent	T8 12W 4' LED
1 lamp	32 watts	32 watts	12 watts
2 lamp	59 watts	63 watts	24 watts
3 lamp	88 watts	95 watts	36 watts
4 lamp	117 watts	126 watts	48 watts

or access to natural daylight. Teachers and students would find it hard to get much accomplished without the aid of artificial lighting. Typical classrooms have rectangular shaped overhead lighting fixtures that house 2-4 fluorescent lamps each. There are many types of lamps that vary widely in efficiency. These tube-like lamps are measured in 8ths of an inch. For example, a T-12 lamp has a diameter of 12/8" or 1.5". A T-8 lamp measures 8/8" so it is has a diameter of 1". The smaller the diameter, the more efficient the lamp is. There are many schools that are replacing older T-12 lamps with more high performance T-8 or T-5 lamps or LED.

A light fixture's efficiency depends not only on the efficiency of the lamp, but on the ballast as well. The ballast is the component that kick starts the lamp when the switch is turned on and electricity is sent to the fixture. Older magnetic ballasts were inefficient at regulating the current running through the lamp, resulting in a poor power factor. Today, electronic ballasts are typically installed in new fixtures and are much more efficient at starting and operating fluorescent lamps.

When calculating the watts used for a school light fixture, there are several factors to be considered; number of hours the lights are on, the wattage of the lamp, the number of lamps, and the type of ballasts. For more accuracy, determine the type of ballast and incorporate the ballast factor into your calculations. (This is beyond the scope of this activity.)

There are many large space areas, such as gyms and cafeterias, that may use different lighting fixtures, such as metal halide or high pressure sodium, but that is also beyond the scope of this activity.

An example of a typical classroom lighting scenario includes a room with 18 fixtures with 3 T-8 lamps in each fixture. See the ***Approximate Wattages for Fixtures*** table (also on the ***Lighting Comparison Activity Sheet***). The lights are turned on at 7:00 am and left on until 4:00 pm five days/week (9 hours/day × 5 days/week × 4 weeks/month = 180 hours/month).

$$\frac{18 \text{ fixtures} \times 88 \text{ watts/fixture} \times 180 \text{ hours on/month}}{1000 \text{ watts/kilowatt}}$$
$$= 285.12 \text{ kilowatt-hours (kWh)/month}$$

To calculate lighting costs in your home, first determine the electric rate ($/kWh) by looking at your residential electric bill. Typical rates range between $0.10/kWh and $0.15/kWh (as of 2018). Note: rates are generally increasing annually due to an increase in demand and cost of natural resources to supply the generation facilities.

For calculating school lighting costs, first determine the blended electric rate for your school (see the **Getting Ready** section).

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your school's electric bill. If you do now know your school's blended rate use $0.12/kWh.

Determine the type, wattage, and number of lamps in the lighting fixtures in your classroom. Consult with a custodial staff member or the facilities manager if you are unable to determine this on your own.

Related KEEP Activities:

Have students conduct the activity "Cost of Computers" to identify ways to save money and electricity when using computers.

Lighting costs can be calculated by multiplying the kWh used over a given time by the electric rate.

0.8 kWh/day x $0.10/kWh = $0.08/day

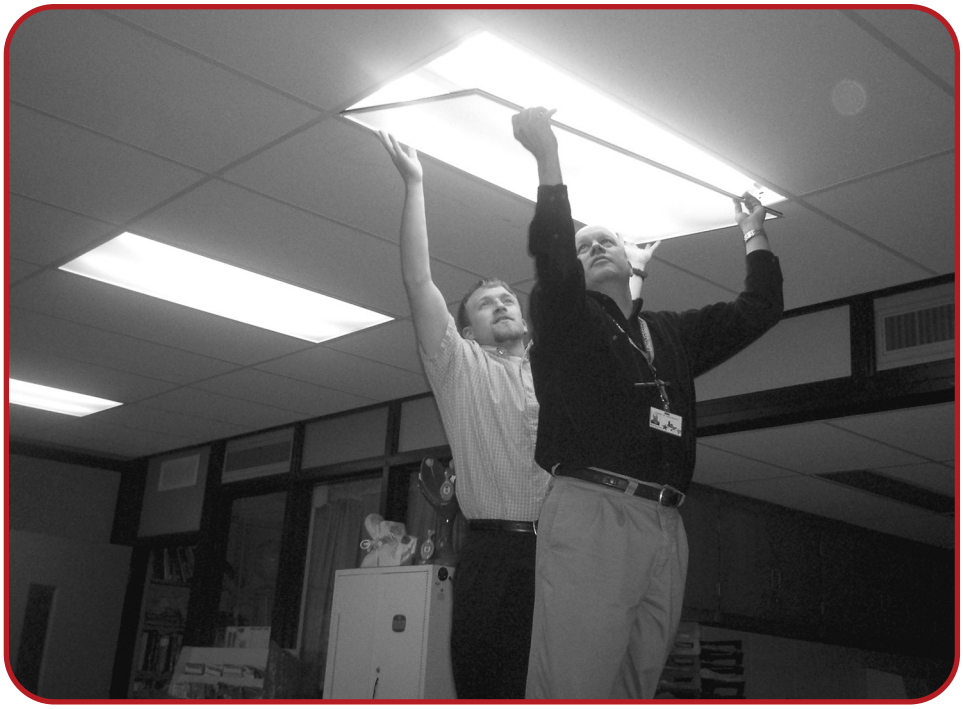
- OR -

285.12 kWh/month x $0.12/kwh = $34.21/month

In homes, lighting accounts for approximately 8% of electrical usage. By using efficient lighting options, such as LEDs/CFLs, people can cut their electric bills by a few percent.

Since lighting accounts for 10-15+ % of a school's electrical consumption, it is important to understand how conserving electricity in the classroom can add up to substantial savings for the school district. For example, if possible, turn off some of your overhead lights if they are not needed. If your lights are not wired in a way that allows you to turn some off, a simple way to save energy is to remove some of the lamps in fixtures where the area is over lit. Be sure to consult your facilities manager before attempting any de-lamping projects on your own.

If you have identified areas in which the school district can save energy, have discussed them with the facilities manager, and are still in need of further assistance, contact the Focus on Energy Agriculture, Schools and Government Program. Search online for Focus on Energy Advisor Map to identify the Advisor in your area.



Procedure

Orientation

Ask students what they think their parents/guardians pay for electricity each month. What percent of a typical family's electrical consumption is used for lighting? How much does it cost for all of the electricity used at school each month? How much does it cost to light their classroom for a month?

Steps

1. Hand out the ***Lighting Comparison Activity Sheet.*** Review the Introduction and At Home section as a class.
2. Assign students to complete the At Home section of the lighting survey. A calculator may be used to assist with calculations (optional). Encourage students to have adult family members assist with the project. NOTE: It is advisable to secure parental permission prior to conducting surveys.
3. Provide the type and number of lamps in each overhead fixture in your classroom along with the blended electric rate for the school. Have students complete the At School section of the lighting survey in class.

Closure

After the At Home section is completed, review the worksheet as a class. Focus on the four comparison questions on the second page to generate class discussion.

Assessment

Formative

- How well did students complete the ***Lighting Comparison Activity Sheet***?
- Were students able to determine if the school currently uses the most energy efficient lighting options?
- Were students able to identify ways to educate other students and staff about the cost of lighting?

Summative

Have students calculate the cost of lighting their classroom with a more or less efficient lighting option. What are the savings/costs associated with the 'new' lighting option.

Extension

Ask the facilities manager to speak to the students about the lighting in the school. They could explain any updates that have been made at the school and discuss how much money was actually saved. They could also provide suggestions for how students could save energy in other ways in the school.

Involve students in a thorough lighting survey of the entire building. Meet with the Facilities Manager to determine the percent of electricity used on lighting for the school. Using a light meter, record interior light levels of classrooms and common areas to determine which spaces are over lit. (See ***Recommended Interior Light Levels in Schools*** chart.)

If lighting upgrades are needed, have students report their findings to the superintendent or school board with recommendations.

Lighting Comparison Activity Sheet

Introduction

How much does it cost to provide electricity for lighting? Are some types of lighting more cost effective than others? To answer these questions, you will calculate electricity costs for some of the lights you use in your home and school.

At Home

Use the table below to calculate the cost of lighting the four most frequently used rooms in your home. An example of the calculations needed has been provided on the first row.

Before you do the calculations, find out how much a kilowatt-hour (kWh) of electricity costs in your area. This information can be found on your utility bill. Write your answer below.

A._____ **(If you can not determine your electric rate, use $0.10/kWh)**

Name of Room	**B. Fixtures** # and watts per bulb**	**C. Watts** # watts used when on	**D. Hours on/day** Average # of hours/day that light bulb is on	**E. Watt-hours used per day** watts (C) × hrs (D)
Example: Kitchen	***4 – 60 watt bulbs***	***= 240 watts (4 bulbs × 60 watts)***	***4 hours/day***	***= 960 watt-hrs/day (240 watts × 4 hrs/day)***
F. Total watt-hours per day for four rooms. Add together totals from (E) for all rows				

** If you have fluorescent tube lighting, use table on next page to determine typical wattages

G. Calculate the watt-hours used in one month. Total watt-hours per day (F) × 30 days
Example: (960 × 30 = 28,800 watt-hours)

H. Calculate the total kilowatt-hours (kWh) for one month. Watt-hours (G) divided by 1,000 watts
Example: (28,800 / 1,000 = 28.8 kWh)

I. Calculate the cost of lighting four rooms for one month. Total kilowatt-hours for one month (H) × cost of electricity (A)
Example: (28.8 × 0.10 = $2.88)

J. Calculate the lighting cost for one year. Cost of lighting four rooms for one month (I) x 12 months
Example: ($2.88 × 12 = $34.56)

At School

Use the table below to calculate the cost of lighting a typical classroom in your school. An example of the calculations needed has been provided on the first row.

Before you do the calculations, find out how much the blended rate for a kilowatt-hour (kWh) of electricity costs at your school. This information can be found by taking the total amount due on your school's electric bill and divide by the total kWh used (on-peak and off-peak). Write your answer below.

A._____ **(If you can not determine your school's blended electric rate, use $0.12/kWh)**

Classroom Name/Number	**B. # of Fixtures** for the entire classroom	**C. # of Lamps** per fixture* usually 2, 3, or 4	**D. Type of Lamp** T-5 or T-8 or LED	**E. Watts per fixture*** see table below for general wattages	**F. Hours on/ day** Average # of hours/day fixtures are on	**G. Watt-hours used per day** fixtures (B) × watts/fixture (E) × hrs (F)
Example: KEEP Office	*4*	*3*	*T-8*	*88*	*8*	*4 x 88 x 8 = 2,816 watt-hrs*

* If you don't know the #, wattage, or type of lamp, use 126 watts/fixture

H. Calculate the watt-hours used in one month.
Total watt-hours per day (G) x 22 days (M-F only)
Example: (2,816 watt-hrs × 22 days= 61,952 watt-hrs)

I. Calculate the total kilowatt-hours (kWh) for one month.
Watt-hours (H) divided by 1,000 watts
Example: (61,952 watt-hrs / 1000 = 61.9528 kWh)

Approximate Wattages for Fixtures			
	T8 32W 4' fluorescent	**T5 28W 4' fluorescent**	**T8 12W 4' LED**
1 lamp	32 watts	32 watts	12 watts
2 lamp	59 watts	63 watts	24 watts
3 lamp	88 watts	95 watts	36 watts
4 lamp	117 watts	126 watts	48 watts

Source: Xcel Energy Lighting Efficiency Input Wattage Guide

J. Calculate the cost of lighting a classroom for one month. Total kilowatt-hours for one month (I) × cost of electricity (A)
Example: (61.952 × 0.12 = $7.43)

K. Calculate the lighting cost for one school year. Cost of lighting classroom for one month (J) × 10 months
Example: ($7.43 × 10 = $74.34)

Comparing Lighting at Home and at School

1. Does it cost more to light the four most frequently used rooms in your home or your classroom?

2. How much would it cost to light all the classrooms in your school for a school year? In your school district (estimate total # of classrooms)?

3. Does your school currently use the most energy efficient lamps and fixtures?

4. How could you educate the staff and students in your school about the cost of lighting?

Recommended Interior Light Levels in Schools

Involve students in a thorough lighting survey of the entire building. Using a light meter, record interior light levels of classrooms and common areas to determine which spaces are over lit. Be sure to take three measurements in each room under typical lighting conditions. Compare the room average to the chart below. Meet with the facilities manager or principal to share your results and recommend changes.

Application	Foot-candles
Administrative Offices	50
Auditorium	
Assembly	10
Social activities	5
Reading	30-50
Bathrooms	
Grooming	30
Lavatory	15
Cafeteria	
Dining area	30
Kitchen	50
Classrooms	50
Computer Lab	
Keyboards	30
Monitors	3
Reading printed material	50
Drafting Room	75
Gymnasium	
General exercising and recreation	30
Basketball/Other games	50
Hallway	30
Library	
Stack, audiovisual, checkout areas	30
Open study areas	50
Shop Areas	30-75
Source: Illuminating Engineering Society Lighting Handbook and Industry Practices, 2015	

Excerpt from

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