

Lesson Plan: Household Conservation / Efficiency

Concepts

1. Energy conservation can be defined as the protection, preservation, management, or restoration of our energy resources.
2. Conservation is one of the ways we can reduce energy use, thus reducing the amount of pollutants put into our atmosphere from the burning of fossil fuels and reducing the negative effects felt from the burning of these fuels.
3. Conservation methods include modifications to our daily behaviors to reduce energy consumption (e.g., turning off light bulbs).
4. Efficiency can be achieved by choosing energy conscious products. These products still provide work, light or heat, but do so with less energy consumption than less efficient products.

Key Questions

1. What appliances use the most energy in the average home?
2. What are some ways you can conserve energy in your home?
3. What are some examples of energy conscious products?

Student Learning Objectives

The student will be able to calculate energy use and analyze how changing their behaviors and appliances will affect the energy their use.

The student will be able to conduct an experiment and make comparisons based on experimental evidence

Educational Standards

NCTM Math (6-8): A1.1, A1.4, A2.2, A3.1, B3.1, D1.1, D1.2, D2.2, E3.1, I3

NSSES Science (5-8): A1.4, A1.5, A1.7, A1.8, A2.3, B3.1, B3.4, F5.1, F5.3

ITEA Tech: 6, 10, 16

Anticipatory Set

- o We use energy in our lives everyday. Our homes use energy in many ways. Our home heating/cooling systems are the largest consumer of energy in most U.S. households. Heating water is also a large energy consumer. Another large energy consumer category is electric lighting and appliances. (refer to data in the excel graphing activity, Unit 1, for specific information)
- o Our homes are filled with appliances that use electrical energy to work for us. Toasters, microwave ovens, televisions, and computers are some examples of the appliances we use everyday. We compare electrical energy use in units called watt-hours or kilowatt-hours.

- o Lighting accounts for 20-25% of all the electricity used in the United States. On average a household uses 5-10% of its energy for lighting. A commercial industry on the other hand consumes 20-30% of their energy in lighting only. 50% or more of the energy used is *wasted by obsolete equipment, inadequate maintenance, or inefficient use.*
- o Consumer demand for appliances that turn on quickly and LED lights that stay on all the time create a constant “stand by” power requirement that can be very substantial. This power is sometimes called “leaking electricity.” Unplugging these appliances is the only way to reduce the stand by power load.
- o Energy savings for lighting will require either reduction in use or more *efficient* usage.
- o New technologies have provided significant reductions in the power needed for lighting. See Energy Star light bulb rating http://www.energystar.gov/index.cfm?c=cfls.pr_cfls

75W incandescent equivalent bulbs					
Compact fluorescent light bulbs (CFLs) http://eartheasy.com/store/proddetail.php?prod=1100.942		18 W (76% energy savings)	8,000 h	\$22/ 5 pk	Requires special bulb recycling to collect and contain mercury
Cold cathode fluorescents (CCFL's) 18 watts = 75 watt incandescent equivalent http://www.betterbulb.com/		18 W (76% energy savings)	25,000 h	\$20	Low energy costs Less mercury than CFLs
Light Emitting Diode (LED) The 5 Watt LED light is - o efficient and cost effective - o the most powerful direct replacement bulb - o fits standard sockets http://www.earthtechproducts.com/p2637.html		5 W (93% energy savings)	Not specified	\$60	No Hg Expensive

Key Terms

Incandescent bulb	Traditional light bulb that converts electricity to light by heating a thin wire until it glows
Energy Audit	A study of energy use and losses in a home, business or other system
Life cycle cost analysis	Analysis of the total capital and operating cost of a product
Compact Fluorescent Light Bulb (CFL)	A new light bulb that converts electricity into light through the excitation of
LED	A Light Emitting Diode (LED) is a solid-state semiconductor device that converts electrical energy directly into light. The process of an electron moving in the semi-conductor releases energy and produces photons with visible wavelengths.

Teaching Plan:

This is a multi-day lesson that includes basics of home electricity use, use of a watt meter to measure power, a home energy audit, and an experiment and lifecycle costing to explore the value of CFLs and LEDs.

Day 1:

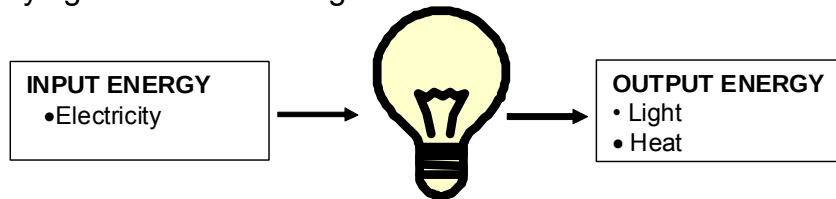
- Focus on energy consumption at the home– review graphs that were done in the intro – how much energy we really use. Identify Conservation as one way to reduce energy consumed – a good choice for culminating project!!
- But - In order to reduce how much fossil fuels we use in our homes (how much energy we use) we need to know how much we currently use and what are options are for reducing that use
 - o Conservation – not using consumer energy product (e.g., turning lights off, walking instead of driving)
 - o Efficiency – benefiting from the value of using energy (e.g., still being mobile), but consuming much less energy to meet same goal (e.g., automobile with high MPG)
- Introduce **Home Electricity Use**
 - o Begin with discussion about where energy is consumed in the home. Compare “energy” – thermal vs. electricity (revisit relative amounts from graphing activity)
 - o Focus on electricity consumption.
 - o Basic concepts needed:
 - $\text{energy} = \text{Power} \times \text{time}$,
 - (units: kWh = W/1000 x hours)
 - $\text{power} = \text{energy} / \text{time}$ (units: W = (kW-h)1000 / h)
 - $\text{power} = \text{volts} \times \text{amps}$ ($P = I V$)
 - volts – a measure of potential for electricity; like the height of water behind a dam (120 V = standard household voltage in USA).
 - Current a measure of the flow of electricity, like the flow rate of water through the dam
 - o Ask: how do we know how much electricity an appliance is consuming?
 - Look at appliance rating – watts? Amps? Watts = amps x volts (good to have examples – hair dryer to show this)
 - Look at tables of “average” wattage (note age of appliance – e.g., refrigerator – see tables in home energy audit activity)
 - Reinforce concepts
 - $\text{energy} = \text{Power} \times \text{time}$,
 - (kWh = W/1000 x hours)
 - so appliances that are used for a long time but lower wattage might consume same energy as appliance used for short time period but at high wattage (power)
- **Complete watt meter activity** - Use Watt-Meter (distribute, play with these with various devices – hair dryer, microwave, coffee pot, computer etc)

- Internet Search for “Kill-A-Watt EZ Plug Power Meter” or “Watts Up Portable Plug In Power Meter” prices range from \$20-\$100 each
- Distribute the **home energy audit activity**, explain that they can enter data onto hard copy provided or use the excel spreadsheet. Your students can also enter the data into the Central Maine Power version that is menu-driven (<http://www2.cmpco.com/EnergyCalculator/input.html>).
- What is “leaking electricity”? (good – but optional)
 - Discuss this concept
 - demonstrate watt meter to measure leaking electricity
 - Be sure to include this in energy audit!!
- How much does electricity cost? Provide average electricity cost or can look at energy bills to determine real numbers for our area.
- Close by carefully reviewing with students what they need to accomplish with the home energy audit homework and explain why it is so important for their semester project. (need to understand the problem before you can solve the problem)

Days 2-3:

- Review findings of home energy audit (if done or wait 1 week to review) – note which appliances use most electricity. How can this information be used to identify problem areas and ideas for changes in your lifestyle leading to conservation, or changes in the equipment used, leading to increased efficiency of your energy use?
- Review the concept of conservation – compare that to efficiency. Tell the students that today, they will be looking at a specific **efficiency** issue - the use of different types of light bulbs. (2min) (Note – conservation = turning off light bulbs, efficiency = using bulbs to produce light with less electricity)
- Note that new technologies (developed by scientists and engineers!!!) can bring about substantial savings in energy use but still provide us with the benefits of electrical lighting
- Light and Heat Bulb Activity (30-35 min)
 - o Break the students into groups of 3-4
 - o Hand out the activity sheets and go over the procedure (5 min)
 - o Suggested supplies:
 - Incandescent bulb (60 Watt) with light socket/plug (each group)
 - Compact Fluorescent Light Bulb (CFL, 13 Watt) with light socket/plug (each group)
 - Infrared (IR) thermometer (could be shared among a couple of groups)
 - LED bulb with light socket/plug (one station)
 - light meter (one per class)
 - ruler (each group)
 - o You will provide the lux reading for each bulb
 - o For Part II it is better to work as a class or in very small groups (1-2 students). This can be started as they wait for the light bulbs to heat up.

- o As demo or extra station, introduce LED bulbs (light emitting diode)
 - See notes above
- Discuss reasons for increased efficiency – light – the desired energy “product but varying amounts of heat generated also”



- Go over conservation and efficiency ideas (perhaps on the board) and spend a minute or two talking about the final project. Tell the class that they will need to define their ideas.

Resources

Watt Meter Activity (included below)
Home Energy Audit Activity (included below)
Light vs. Heat Bulbs Activity (included below)
 Leaking Energy Fact Sheet (included below)
 Energy Efficiency Fact Sheet (included below)
 Watt meters, various appliances
 Lux meter
 Light bulbs and fixtures
 IR thermometers

Lesson Assessment

Light Bulbs activity sheet and homework
 (this homework may be redundant if thorough home energy audit also done)
 Home energy audit homework/activity sheets

URL

All lesson plans in this unit are included at
<http://www.clarkson.edu/highschool/k12/project/energysystems.html>

This URL has been included in the Engineering Pathways web site
 (<http://www.engineeringpathway.com/ep/index.jhtml>) and can be found with a search on “energy choices.”

Owner

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Contributors

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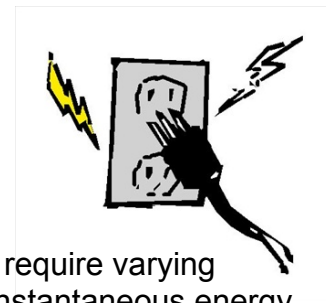
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Activity: Watt meters to measure energy consumption

Background and Purpose



We use electricity in our lives everyday. Electrical appliances require varying amounts of power to operate. Power (watts) is a measure of the instantaneous energy usage. Measuring the power use of an appliance and the time it is used can be used to calculate the total electrical energy consumed

$$\text{Energy} = \text{Power} \times \text{time}$$

$$(\text{kWh} = \text{watts}/1000 \times \text{hours})$$

Watt meters provide a convenient way to measure power consumption. Power consumption can also be determined through the appliance rating stamped on the appliance. For example, light bulbs are rated as “75 W” or “100 W” to indicate that they use more or less power and, therefore, produce more or less light.

The purpose of this activity is to test the power consumed and estimate the energy consumed by several household appliances.

Supplies

1. Watt meter for each group of 3-4 students
2. 6-8 electrical appliances (examples could include: hair dryer, microwave, hot pot, radio, small TV, computer, cell phone or battery recharger, toaster, lamp with light bulb; string of LED or standard holiday lights, etc.)

Procedure

1. Break into groups of 3-4 students and get a watt meter
2. Starting at the first station you are assigned,
 - a. Plug the watt meter into the wall and the appliance into the watt meter.
 - b. Play with the watt meter to find the setting that reports “power,”
 - c. Record the watt reading and name of the appliance on the data sheet.
 - d. Explore the potential impact of various settings on the power consumption (for example, low versus high setting on the hair dryer). Record the power consumed.
 - e. Estimate the time you use this appliance at home, record that time on the data sheet.
3. Rotate among other stations at the direction of your teacher and repeat step 2 for the other appliances
4. Calculate the energy consumed for each appliance on the data sheet
5. Answer the discussion questions.

6. If time permits, complete the extension activity (following the discussion questions).

Watt meter Data Sheet

Enter information for each appliance in one row of this table. If there are multiple settings tested for the appliance, you can use multiple rows.

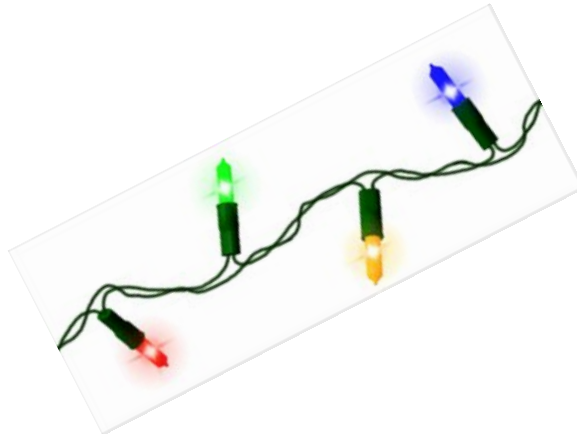
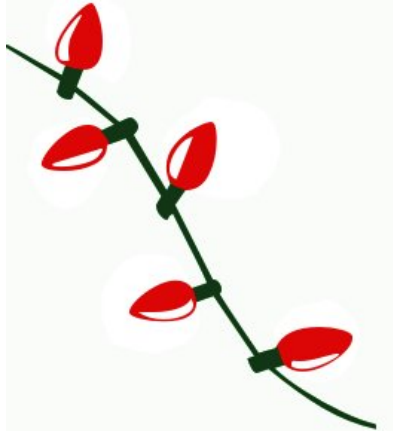
Appliance name	Setting / comments	Power or current specified on appliance	Power (W) (measured)	Estimated time used daily (h)	Energy consumed daily (kWh)*

* energy (kWh) = power (W)/1000 X time (h)

Discussion questions

1. Which of the appliances had a known power rating or current (amps)? How did your measured power compare with the power specified on the appliance? Discuss any differences. (Note – if current (amps) was specified, power can be calculated as $\text{Power} = \text{volts} \times \text{amps}$; the voltage of standard power outlets is 120 V)
2. Which appliance did you expect to use the most **power**? Why? Did you find this to be true?
3. Of the appliances tested, which one did you calculate to use the most **energy** in your home each day? Is this what you expected? Why?
4. Based on the measurements made in this activity, Can you suggest a way that you can conserve energy in your home?

5. Extension Activity: comparing holiday lights.



Measure and record the watts consumed by the regular and the led string of holiday lights (make sure they are about the same length)

Regular lights = _____ Watts

LED lights = _____ Watts

A regular string of lights that consumes 100 watts, left on for 4 hours a day for 2 months (60 days), would consume 24 kilowatt-hours (kWh) of electricity. Using the watts you measured for your 2 strings of lights, how long would you have to leave them on to consume 24 kWh of electricity?

Regular lights:

LED lights:

Based on your calculations, which string of lights do you think is better to buy? Why?

Activity: Home Energy Audit



Purpose

We use energy in our lives everyday. Every activity that we perform requires energy in some form. Even simple functions like walking to the store or to school require energy. Our homes are filled with appliances that use electrical energy to work for us. Toasters, microwave ovens, televisions, and computers are some examples of the appliances we use everyday. We compare electrical energy use in units called watt-hours or kilowatt-hours. Some typical electrical energy usages are included in the table below.

<i>Average U.S. Household Electric Consumption for Major Electrical Appliances</i>	
Appliance	Annual kWh Consumption per Household
Central Air Conditioning	2,667
Water Heater	2,671
Freezer	1,204
Refrigerator	1,155
Water Bed Heater	960
Clothes Dryer	875
Room Air Conditioning	738
Range / Oven	458
Dishwasher	299
Clothes Washer	99

Adapted From:

<http://www.uwsp.edu/cnr/wcee/keep/Mod1/Whatis/energyresourcetables.htm#Wattages%20of%20Small-%20and%20Medium>

But that is not all... your appliances might be “leaking” electricity. Many appliances never stop using electricity, even when they are turned off. For example, if your TV has a remote, then part of the TV is always on “standby mode” so it’s ready to receive the signal from the remote to turn on. If there is a clock on the stove, this is always drawing electricity even though the stove is turned off. If you leave your cell phone charger plugged into the wall, it is using electricity even when you don’t have your cell phone plugged into the charger.

Experts call this usage “standby consumption” or “leaking electricity.” Although a single appliance usually only leaks a small amount of electricity, the total amount of leaking electricity consumption in a household can be significant.

The purpose of this activity is to learn more about the amount of electrical energy used by different activities at home. We do this by calculating the energy consumption of various appliances around your home.

Procedure

1. Use the “Tips for Energy Audit” to help you get started.
2. Chose one room in your house for your audit – the room should have at least 5 electricity consuming appliances/lights.
3. Determine the wattage for each of the power consuming appliances or lights in your room, enter into the table using one row for each light bulb or appliance.
4. Record the time that each of the power consuming appliances is on for each day of 1 week

5. Identify which of the appliances consume energy even in the hours they are off. If possible, estimate the watts consumed in stand by mode through the use of a power meter, appliance manual, or an internet search. (or use the tables provided).
6. Fill out the energy use tables – either the excel spreadsheet version or paper copy data sheet. There is one table for appliances when they are on and another for leaking electricity.
7. Calculate the energy used and cost of energy used
$$\text{energy (kWh)} = \text{power(W)} / 1000 \times \text{time(h)}$$
8. Answer the discussion questions

Discussion Questions – Energy Audit

1. What three appliances consume the most electrical energy at your house?
2. Does an appliance or device that has a high wattage always use the most energy over the week or month? Explain.
3. What do you think you could do to reduce the amount of energy used in your house?
4. Electrical Energy is one of the critical energy resources in our daily lives. Describe how you might replace the work of three of the appliances / devices if you did not have electricity.
5. How does your electricity usage compare with the New York State Averages? (hint – see graphing activity that we did in class)
6. How does the amount of leaking electricity consumption compare with the total amount of electricity used in your household? Can you think of ways to reduce the leaking (stand-by) electricity use?

Wattages of Small- and Medium-Sized Electrical Appliances and Equipment Found in Homes and Schools

Home Appliance	Wattage (Watts)
<i>Heating/Cooling</i>	
Dehumidifier	645
Fans	
Ceiling	100
20-24" Window	200
Oscillating	88
Portable Humidifier	88
Portable Space Heater	1,500
Water Bed Heater	350
<i>Home Office and Entertainment</i>	
Fish Aquarium	
Filter	10
Heater	100
Pump	10
Home Computer (Standard)	150
Printer	
Ink Jet	19
Laser	175-275
Movie or Slide Projector	150
Sewing Machine	75
Solid-State Radio	15
Stereo	110
Television	
Color	200-350
Black & White	40-160
Typewriter	60
VCR	40
<i>Kitchen</i>	
Blender	400
Broiler	1,500
Can Opener	120
Coffee Maker	1,400
Corn Popper	
Hot-Air Type	1,200
Oil-Type	575
Food Chopper	360
Food Processor	360
Frying Pan/Skillet	1,300
Hot Plate	1,100
Kettle	1,500
Microwave Oven	750
Mixer	
Hand	120
Heavy-Duty	210
Toaster	1,000
Toaster Over	1,350
Waffle Maker	1,200
<i>Laundry/Utility</i>	
Iron	1,000

Vacuum Cleaner	650
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Home Appliance	Wattage (Watts)
<i>Personal Care</i>	
Blanket	200
Curling Iron	40
Hair Dryer	
Blower	1,200
Blower/Styler	600
Hood-Type	1,200
Soft Bonnet	400
Heating Pad	50
Shaver	14
Toothbrush (Electric)	7
<i>School Equipment</i>	
Aquarium Pump	4
Aquarium Heater	100
Computer (Standard)	150
Photocopier	Up to 2,500
Ditto Machine	65
Electric Typewriter	Less than 50
Film Projector	350
Opaque Projector	1,000
Overhead Projector	500-850
Printer	
Ink Jet	19
Laser	175-275
Record Player	30-100
Slide Projector	500
Tape Recorder	6-100
Television	
Black & White	40-160
Color	200-350
VCR	40

Adapted From:

<http://www.uwsp.edu/cnr/wcee/keep/Mod1/Whatis/energyresources.htm#Wattages%20of%20Small-%20and%20Medium>

Some Tips for the Energy Audit

1. Before you start, walk around your house with your printout to make sure you haven't overlooked any major appliance. Don't forget things like clocks and aquariums that run 24 hours a day. Pay particular attention to your own room – after all, that's where you can make the most difference!
2. Because you can't be everywhere at once, get your family to help! Give others a copy of the printout and ask them to be responsible for different things in the house, for example make one person responsible to track TV use, another washing machine use, and so on.
3. Try to make day 1 a typical work or school day:
 - a. Make note of the first major electrical uses of the day – lights, kitchen area, blow dryers...
 - b. If someone stays at home while you are at school, ask that person to track use for the day
 - c. When you come home from school, make sure you track your own use of computer, TV, stereo, etc.
 - d. Peak energy hours for most families during the week are in the evening, when cooking, watching TV, homework, and hobbies are all happening at once. You may need help tracking all of these!
 - e. When day 1 is over, add up all of the hours of use for each appliance and plug the total into your personal energy meter worksheet – on paper or on the computer.
4. If possible, determine the power consumed by appliances when they are "off." Many appliances consume power at all times in "stand by mode," which enables them to turn on quickly.
5. Days 2 through 5 should follow pretty much the same pattern, just be aware of special changes to the routine that may affect energy use.
6. If days 6 and 7 fall on the weekend, expect very different energy usage patterns. You'll probably notice that appliances are used all day long, but not all at the same time. It takes good detective work to keep up with it all!
7. At the end of day 7, put your final usage figures into the table and check out the grand total, in kWh and dollars.

Personal Energy Meter

*Energy cost based on total kWh (kilowatt-hours) X cost per kWh. Use default electric cost of \$0.15/kWh or enter another value:

0.15

Column: A	B	C	D	E	F	G	H	I	J	K	L	M
	Energy Tracker (Hours/Day)							Cost Calculator				
Appliance	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Total Hours	Wattage	Total Wh	Total kWh	Energy Cost*
Television (19")	1.50	2.50	2.00	1.00	2.50	2.50	3.00	15.00	100		1.50	\$0.23
Space heater	4.00	3.50	5.00	6.00	5.50	4.50	5.00	33.50	1500		50.25	\$7.54
Personal computer	2.00	1.00	1.50	0.00	1.00	2.00	2.50	10.00	200		2.00	\$0.30
								0.00			0.00	\$0.00
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								0.00			0.00	\$0.00
								0.00			0.00	\$0.00
Total for Week:											53.75	\$8.06

Personal Energy Meter - Leaking Electricity

*Energy cost based on total kWh (kilowatt-hours) X cost per kWh. Use default electric cost of \$0.15/kWh or enter another value:

0.15

Are your appliances leaking electricity? Use the Watt Meter or the information provided to determine which appliances in your household are using electricity when in standby mode. Enter the information in the table below.

Column: A	B	C	D	E	F	G	H	I	J	K	L	M	
	Energy Tracker (Hours/Day appliance is OFF)							Cost Calculator					Comments
Appliance	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Total Hours	Leaking Watts	Total Wh Leaked	Total kWh	Energy Cost*	
Television (19")	22.50	20.50	22.00	23.00	21.50	21.50	21.00	152.00	4		0.61	\$0.09	example
Space heater	20.00	21.50	19.00	18.00	18.50	19.50	19.00	135.50	5		0.68	\$0.10	example
Personal computer	22.00	23.00	22.50	24.00	23.00	22.00	21.50	158.00	10		1.58	\$0.24	example
								0.00			0.00	\$0.00	
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								0.00			0.00	\$0.00	
Total for Week:											2.87	\$0.43	

Part 2 –What If...

The spreadsheet based home energy audit provides a convenient way for you to explore how changes in your energy efficiency or conservation could be used to save electric energy. Some examples of possible areas you can explore include:

Efficiency measures	Conservation measures
- o Replace appliance with an Energy Star appliance (see www.energystar.gov) - o Replace light bulbs with CFLs - o Replace Plasma TV with LED TV	- o Watch TV less - o Turn off lights - o Turn off your computer at night - o Don't use your hair dryer (or other optional appliance) - o Unplug appliances that have high stand by power requirements when not in use

You will need an excel spreadsheet version of your home energy audit to do this part of the activity.

1. Open your spreadsheet file and save it under a new name.
2. Review your week's worth of energy statistics, note the one or two rows that seem especially prominent to define the "energy hogs" in your household. It could be the appliance that's used for the longest time, or the one that uses the most wattage.
3. On your "What If" sheet, try experimenting with your energy hogs:
 - a. Change the wattage or usage (time) values and note if your changes make a difference in your overall electric energy consumed.
 - b. Make a new column that explains the changes you made to each row and why.
 - c. Estimate the total savings you can achieve by comparing your actual home energy audit results with your What If spreadsheet.
4. As a class, create a table of each students' actual energy use and projected "What If" energy use. Estimate the total energy and dollars your class can save if you implement these changes

Discussion Questions

1. What changes can you realistically make that can have a significant impact on your energy consumption and family's energy cost? Would these changes create any "hardship" for you or your family (cost or lifestyle)? Discuss the trade offs between these costs and the benefits of saving energy.
2. Using the results of this activity, propose three ideas that you can use for your final project.
3. Using the number of families in your community as your basis, extrapolate the results of your class' savings to the whole community. How much money could your community save on home electricity alone? Discuss how you might communicate these findings to your community. (This could make a great final project too!)

Activity: Light vs. Heat Bulbs

Purpose

Lighting accounts for 20-25% of all the electricity used in the United States. On average a household uses 5-10% of its energy for lighting. A commercial industry on the other hand consumes 20-30% of their energy in lighting only.

50% or more of the energy used is *wasted by obsolete equipment, inadequate maintenance, or inefficient use*. Energy savings for lighting will require either reduction in use or more *efficient* usage. The purpose of this activity is to:

- Compare the two most common types of electric lighting: incandescent bulbs and compact fluorescent bulbs (CFL)
- Introduce the latest technology in lighting and light bulbs
- Determine which is more energy efficient and cost effective



Equipment

1. Incandescent bulb (60 Watt) with light socket/plug
2. Compact Fluorescent Light Bulb (CFL, 13 Watt) with light socket/plug
3. LED bulb with light socket/plug
4. Infrared (IR) thermometer
5. light meter
6. ruler

Procedure

1. Break into groups of 3-4 students.
2. Examine your light bulbs. Record the watts consumed by each bulb in the appropriate space on the Data Table (Watts, W).
3. Record room temperature by pointing the IR thermometer at the bulbs before they are turned on. Hold the IR thermometer ~10 cm away from the bulb and point it directly at the center of the bulb surface. This should be the starting temperature for both light bulbs (T_s). Record in Data Table.
4. Turn on both light bulbs.
5. After 10 minutes, measure the temperature from 10 cm away from each bulb. Record these final temperatures (T_f) in the Data Table. Calculate the net change in temperature, ΔT ($\Delta T = T_f - T_s$), for both the incandescent and the compact fluorescent light bulbs. Record in Data Table.
6. Repeat steps 3-5 for demonstration LED bulb if available.
7. Before turning the light bulbs off, your teacher will obtain a measure for the light emitted from each light bulb using a light meter. Record this value (lux) in the Data Table.

	Incandescent Bulb	Compact Fluorescent Light Bulb (CFL)	Light Emitting Diode (LED)
Watts consumed			
Starting temperature, T_s ($^{\circ}\text{C}$)			
Final temperature, T_f ($^{\circ}\text{C}$)			
Change in Temperature $\Delta T = T_f - T_s$ ($^{\circ}\text{C}$)			
Light emitted (Lux)			

Part I. Conclusions

1. Draw three bar charts, one each for light emitted, power rating, change in temperature (one each graph, one bar for each bulb)
2. How does the light emitted by the bulbs compare?
3. If there was a difference, can you give a possible reason why?
4. Which light bulb consumes more power (watts)?
5. Which produces more heat (represented by a change in temperature)?
6. The main purpose of a light bulb is to provide light, not heat. Knowing this, explain the benefits of using compact fluorescent light bulbs instead of incandescent bulbs.

Part II. Life Cycle Cost Analysis

To answer the following questions please refer to the information provided below about 60-Watt incandescent bulbs and 13-Watt CFL (these two bulbs produce the same amount of light).

Categories (units)	Incandescent	CFL
Watts consumed (W)	60	13
Rated Lamp Life (hours)	1000	8,000
Electricity cost per kWh (\$/kWh)	0.10	0.10
Cost per bulb (\$)	0.25	3.00 (average)

1. Calculate the amount of electrical energy consumed by each bulb type over a 8,000 hour period in kilowatt-hours (kWh) ($W \times \frac{kW}{1000W} = kW$):

a. Incandescent bulb:

_____ W = _____ kW

_____ kW X _____ hours = _____ kWh

b. CFL:

_____ W = _____ kW

_____ kW X _____ hours = _____ kWh

2. Calculate the electricity cost per 8,000 hours for each bulb type.

a. Incandescent bulb:

_____ kWh X _____ \$/kWh = \$ _____

b. CFL:

_____ kWh X _____ \$/kWh = \$ _____

3. Calculate the number of bulbs used in the 8,000 hour period.

a. Incandescent bulb:
_____ hours / _____ Rated Lamp Life (hours per bulb)
= _____ bulbs

b. CFL:
_____ hours / _____ Rated Lamp Life (hours per bulb)
= _____ bulbs

4. Calculate the **total** purchase cost of the bulb (or bulbs) used during the 10,000 hours.

a. Incandescent bulb:
_____ # of bulbs used over 8,000 hours X \$ _____ per bulb
= \$ _____

b. CFL:
_____ # of bulbs used over 8,000 hours X \$ _____ per bulb
= \$ _____

5. Now calculate the **Total Life-Cycle Cost** for each bulb type over an 8,000 hour usage period. **This is calculated by adding the answer from question 2, the electricity cost, to the answer from question 4, the bulb cost, for each bulb.**

a. Incandescent bulb:
\$ _____ + \$ _____ = \$ _____

b. CFL:
\$ _____ + \$ _____ = \$ _____

6. Create a table summarizing the results of your calculations.

7. Based on your calculations of the Total Life-Cycle Cost for each bulb type, over a 8,000 hour usage period, which bulb would save you money?

8. How much money would you save by your choice for each light bulb?

9. How many light bulbs in your house do you think you can change to CFLs? How much money could your family save over 8,000 hours of light bulb use?

Homework – Home Light Bulb Use

Name: _____



Lighting accounts for 20-25% of all the electricity used in the United States. On average a household sets aside 5-10% of its energy budget to lighting. A commercial industry on the other hand consumes 20-30% of their energy in lighting only. 50% or more of the energy used is *wasted by obsolete equipment, inadequate maintenance, or inefficient use*. Energy savings for lighting will require either reduction in use or more *efficient* usage. The purpose of this homework is to:

1. Determine your current electric lighting situation
2. Decide if you could benefit from changing from incandescent to compact fluorescent bulbs

Fill in the attached chart, following these instructions.

Remember to show all work including formulae, answers, and units.

1. Walk around your house and examine any lights that you may have. Fill in the chart below to characterize your bulbs. Remember the class activity “Light or Heat Bulbs” when identifying the type and power rating of the bulbs. Fill in the columns on Table 1.
2. Convert the rated power of your light bulbs from Watts (W) to Kilowatts (kW) on Table 1. Remember that there are 1000 Watts in 1 Kilowatt.
3. Estimate the number of hours you use each bulb in a day and fill in the appropriate column in Table 1
4. Calculate the daily energy used each day by each bulb type by multiplying and filling in the last column of Table 1:

Total Daily Energy (kWh per day)

= Number of Bulbs x Rated Power (kW) x # of Hours Used per Day (h per day)

5. Sum the values in the last column to find the total amount of energy used by light bulbs in your house each day.

6. To find out how much energy that only the INCANDESCENT bulbs consume in a day, add values in the last column of Table 1 that correspond to only the COMPACT FLUORESCENT bulbs and subtract it from the Total found in step 5. Record this value.
7. You can now find out how much energy you can save by switching your incandescent bulbs to compact fluorescent bulbs.
8. For each type of INCANDESCENT bulb that you found and recorded in Table 1, find its corresponding row in Table 2. In this row, you can see how much power an equivalent compact fluorescent bulb consumes.
9. Copy your information about the “number of bulbs” and “# of hours used per day” from your INCANDESCENT bulbs in Table 1 to their corresponding rows in Table 2.
10. To calculate how much energy that equivalent compact fluorescent bulbs would use in a day, perform the following multiplication and fill in the last column in Table 2.

Total Daily Energy (kWh per day) = Number of Bulbs x Equivalent Compact Fluorescent
Power (kW) x # of Hours Used per Day (h per day)

Questions:

1. How much energy does your home currently use for lighting per day? (kWh/day)
2. How much energy does your home use for INCANDESCENT lights per day? (kWh/day)
3. How much energy would you save by switching to COMPACT FLUORESCENT lights per day? (kWh/day)
4. If you pay \$0.083 per kWh, how much money could you save on your electric bill per year by switching?

Table 1: Your current light bulb situation

Type of Bulb (Incandescent or Compact Fluorescent)	Number of Bulbs	Rated Power (W)	Rated Power (kW)	# of Hours Used per Day (h per day)	Total Daily Energy Consumption (kWh per day)
				TOTAL Energy Use:	
				TOTAL Incandescent Energy Use:	

Table 2: Upgrading to Compact Fluorescent

Incandescent Bulb Power (W)	Equivalent Compact Fluorescent Power(W)	Equivalent Compact Fluorescent Power (kW)	Number of Bulbs	# of Hours Used per Day (h per day)	Total Daily Energy Consumption (kWh per day)
40 W	11 W	0.011 kW			
60 W	13 W	0.013 kW			
75 W	18 W	0.018 kW			
100 W	23 W	0.023 kW			
				TOTAL Compact Fluorescent Energy Use:	

Leaking Electricity – Fact Sheet

Are your appliances **leaking electricity**? Not only do we have more small- and medium-sized appliances than ever before, but many of these never really stop using electricity. For example, if the television has a remote, then part of the TV is always on, waiting for a signal from the remote. If there is a clock on the microwave then the microwave is always using some electricity. Experts call this usage "standby consumption," "phantom load" or "leaking electricity" because people are often not aware that the appliance is using electricity. One way to tell if your appliance uses standby consumption is if the on/off control buttons are smooth, and respond to your finger's touch, as opposed to having to turn or push to turn on the appliance.

A single appliance usually leaks only a small amount of electricity each hour, but since these appliances leak electricity whenever they are not turned on, and since people have a lot of these appliances, the amount of leaking electricity is significant. The average household spends about \$40 every year on leaking electricity. The federal government is working with appliance and manufacturers to reduce the amount of electricity that leaks out of new appliances.

Leaking Watts Chart
Standby Consumption of Some Residential Appliances

Type of Appliance	Stand by power (watts)		
	Min	Avg	Max
Air Conditioner	0.0	0.0	0.0
Alarm Clock	0.7	1.3	2.0
Amplifier	0.0	1.4	5.5
Answer Machine	1.8	3.0	5.2
Cordless Phone	2.5	2.8	3.1
ATX PC	1.3	2.1	2.8
Baby Monitor	0.7	1.2	1.6
Battery Charger	0.2	1.4	3.2
Boom Box	0.7	2.2	7.7
Cable Box	4.8	11.6	18.0
Cassette Deck	0.0	2.8	6.6
CD Player	0.0	3.1	8.0
Clock Radio	0.9	1.7	3.2
Cordless Phone	1.1	2.7	5.0
Dishwasher	6.4	6.4	6.4
DSS	11.3	15.0	18.4
DVD Player	1.6	4.3	7.1
Equalizer	0.0	3.1	5.9
Garage Door Opener	3.5	3.8	4.0
Internet Appliance	7.5	7.5	7.5
Linear Power Supply	0.3	1.3	3.2
Macintosh PC	0.0	2.0	3.5
Massager	1.1	2.7	4.2
Microwave Oven	1.6	3.2	6.0
Mini Disc	4.5	4.8	5.1

Type of Appliance	Stand by power (watts)		
	Min	Avg	Max
Mini Audio System	1.3	9.3	28.6
Modem (external)	1.0	1.4	1.8
Phone/Fax/Copier Combo	3.3	4.7	6.5
Power PC	1.3	1.5	1.6
Power Speaker	0.0	1.6	3.1
Preamplifier/Tuner	1.4	2.4	3.2
Printer	3.5	3.5	3.5
Range	1.8	3.0	4.1
Receiver	0.0	1.8	5.9
Rice Cooker	1.5	2.0	2.5
Security System	15.0	18.3	21.5
Shaver	0.4	0.9	1.4
Television	0.0	4.3	12.3
Tuner	0.0	2.0	4.0
TV/VCR Combo	2.5	9.8	19.5
Battery-Powered Vacuum Cleaner	1.7	2.1	2.6
VCR	1.5	5.6	12.8
Video Game	0.0	1.1	2.0

Adapted from:
<http://www.uwsp.edu/cnr/wcee/keep/Mod1/Flow/leaking.htm>

Making the Home More Energy Efficient - Fact Sheet

How much do we spend?

An average home spends \$1500 on utility bills, but this does not include heating which is on the order of \$1000. Heating makes up for almost ½ of the energy use in typical homes, and lighting and cooking makes up for the next largest amount.[7]

If one looks just at water usage and the amount of hot water produced, they will see that showers are of highest consideration (See Figure 2.)

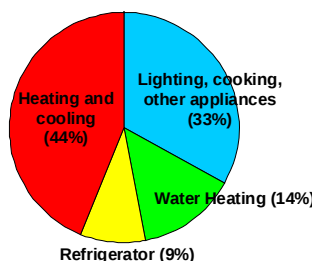


Fig 1: Energy use in the home [7].

ENERGY STAR and EnergyGuide – good alternatives

On the power usage, appliances of greatest usage are that of clothes dryers, refrigerators, and dishwashers (Table 1). ENERGY STAR and EnergyGuide are two manufacturers that utilize energy efficient technology in appliances. For example a refrigerator bought before 1993 requires 2 times the energy as an ENERGY STAR model. By using ENERGY STAR products, some homes could save up to \$450 per year, about 30% of the normal energy bill. [4]



Energy Saving Tips

Below are some easy active energy savers. Although they do not seem to have a great impact, if you pair these precautions with some energy efficient appliances your energy bill will decrease. [7]

- o Air dry dishes instead of using your dishwasher's drying cycle.
- o Use your microwave instead of a conventional electric range or oven.
- o Turn off your computer and monitor when not in use.
- o Plug home electronics, such as TVs and VCRs, into power strips and turn power strips off when equipment is not in use.
- o Lower the thermostat on your hot water heater; 115 degrees is comfortable for most uses.
- o Take showers instead of baths to reduce hot water use.
- o Wash only full loads of dishes and clothes.

Table 1: Typical Appliance Power Usage [2]

Common Appliance Power Usage	# of Watts
Aquarium	50-1210
Clock radio	10
Coffee maker	900-1200
Clothes washer	350-500
Clothes dryer	1800-5000
Dishwasher	1200-2400
Dehumidifier	785
Electric blanket- Single/Double	60/100
Fans	
Ceiling	65-175
Window	55-250
Furnace	750
Whole house	240-750
Hair dryer	1200-1875
Heater (portable)	780-1500
Clothes Iron	1000-1800
Microwave oven	750-1100
Personal Computer	
CPU - awake / asleep	120-30
Monitor - awake / asleep	150-30
Laptop	50
Radio (stereo)	70-400
Refrigerator (frost-free, 16 ft ³)	725
Televisions (color)	
19"	65-110
27"	113
36"	133
53"-61" Projection	170
Flat Screen	120
Toaster	800-1400
Toaster Oven	1225
VCR/DVD	17-21 /20-25
Vacuum cleaner	1000-1440
Water heater (40 gallon)	4500-5500
Water pump (deep well)	250-1100
Water bed (w/ heater, no cover)	120-380

Energy Efficient Precautions

There are many ways that people can make their house more energy efficient without having to install a new energy system. Here are some ways purchase ideas that will save energy and cut the cost of your energy bill.

- o *Weatherization*- plugging gaps, stopping air leaks, and insulating maintains comfort levels and reduces amount of heat that leaves home. This includes finding more efficient windows as well.
- o *Space Heating and Cooling*- Change to Solar or geothermal heat pump. It reduces the amount sulfur dioxide and nitrogen oxides.
- o *Compact fluorescent lights*- Uses 1/4th the amount of electricity that incandescent lamps use. They also reduce carbon emissions.
- o *Energy efficient electric appliances* – Replace old with modern appliances; look for EnergyGuide and ENERGY STAR labels [6,7].

Resources and Sources for Additional Information

1. Energy Efficiency and Renewable Energy <http://www.eere.energy.gov/consumerinfo/>
2. National Renewable Energy Laboratory <http://www.nrel.gov/>
3. EERE, "Reducing your Electricity Load," http://www.eere.energy.gov/consumerinfo/makeelectricity/operate_reduce_e-load.html
4. EERE, "Energy Savers" http://www.eere.energy.gov/consumerinfo/energy_savers/
5. EERE "Energy Solutions Your Building," <http://www.eere.energy.gov/buildings/?flash=yes>
6. ENERGY STAR, <http://www.energystar.gov/>
7. EnergyGuide, <http://www.energyguide.com/>

Compiled by K. Schillemat, 08/05.

