



WATT DOES IT COST TO USE IT?



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Overview: Familiarize students with how electrical usage is counted, electrical pricing, and measure and evaluate representative household and school electrical items.

Objectives: Students will:

1. Learn about electrical energy is measured in units of kilowatt-hrs.
2. Determine the power needs (wattage) of representative electrical items in homes and businesses.
3. Calculate kWh of an appliance when given its power consumption in watts and the amount time that it is on.
4. Learn the law of energy conservation.
5. Recall the dollar cost per kWh for electrical energy in their area.
6. Convert electrical energy in kWh to dollars.
7. Learn to project costs to use representative items for one year.
8. Generalize which electrical items are big users, and which are small, and evaluate the merit of leaving items on against the cost to leaving them on.
9. Feel the personal need to conserve electrical energy.
10. Make an energy inventory of their houses, and make recommendations for conservation.

Subjects: Physical Science, Environmental Science, Physics

California Science Standards addressed:

- Physics Grades 9-12 Physics #3 - Energy cannot be created or destroyed, although in many cases energy is transferred to the environment as heat.
- Investigation and Experimentation Grades 9-12 #1.l - Analyze situations and solve problems that require combining and applying concepts from more than one area of science.
- Investigation and Experimentation Grades 9-12 #1.m - Investigate a science-based societal issue by researching literature, analyzing data, and communicating the findings.

Suggested grade level: 7th - 12th

Time: Approximately 3 periods

Materials:

Medium apple or 100 g mass
Meter stick
Calculator

Representative electrical
appliances
Copied blank table (optional)

Photocopies of a residential
electric bill
Watt meter (optional)

PROCEDURE



1. Have these representative items on display in the front of the room: incandescent lamp, fluorescent lamp, egg beater, space heater, VCR, hair dryer, CD player, clock, computer printer, cell phone charger, TV, toaster.
2. "What is a watt?" Hold an apple or a 100 g mass next to a vertical meter stick, and lift it to the top of the meter stick in 1.0 second time. "How much power did it take to do this? - One watt." Have several students do the same. 1 watt = energy to lift 100 g (or 1 Newton) in 1.0 seconds. Students note that a watt is a small unit of energy. "If I lifted more apples or more weights, it would take more power, more watts."
3. *[Physics and Physical Science only]* Define a watt based on previously covered units: gram, kilogram, and Newton. Give the formula for power: $\text{Power} = \frac{\text{Work}}{\text{Time}}$. Note that increasing the amount of work done increases the power requirement, and decreasing the time to do a task also increases the power requirement.
4. Students read the labels of several electrical items on display. Pass out the blank tables. Students complete the first column of the table. Afterward, students note that some items use far more electrical power than others. Students add the heading to the 2nd column: **BIG Users (>200 W)**, and check off the ones that use >200 W. "Can you make generalizations as to the BIG users?" [Heating items use a lot of power.]



Students put in the heading on the 3rd column: **On > 1 hour/day**, and check the ones that apply. Note that some of the big users, like an egg beater, are on so little that in our electric bills, they do not count for much, but some small users, like a porch lamp, do count for a lot. Tell students that the last four columns are to be completed later.

Day one can end here. Students can complete the first three columns for homework, adding appliances to it by looking up about 5 items from their own homes. If so, discuss their results and conclusions in the next day

5. Define kilowatts and explain how to change watts to kilowatts. $1000 \text{ w} = 1 \text{ kW}$. *[Environmental Science:]* To change watts to kilowatts, divide by 1000. *[Physical Science and Physics:]* Using the factor-label method, the conversion factor for changing watts to kilowatts is $\frac{1\text{kW}}{1000\text{W}}$.
Review the unit abbreviations used so far: W and kW.
6. Recall the definition of energy: the ability to do work. This applies to electrical energy too. Electricity does work for us.
7. Discuss as a class: "Now we will come up with the formula that is used to measure electrical energy. What determines how much electrical energy I use?" [An item's power, and how long it is left on.] We need both of these to get the formula:
 $\text{Energy} = \text{Power} \times \text{time}$, which almost always uses these units:
 $\text{kWh} = \text{kW} \times \text{hrs}$. Note that in this formula, watts must be changed to kW first.
8. Give the fourth to last column in their table the heading **Hours left on/day**. As a class discussion, students estimate that

number of hours per day that the electrical items in their table are left on. Complete this column. Use decimal hours for times less than one hour. Estimates are okay, as all we are doing is approximating.

9. Students give the third to last column the heading **Energy/day**. Now using the energy formula, $\text{Energy} = \text{Power} \times \text{time}$, as guided practice, students calculate the energy use per day or the first several items. Then later complete the entire column. Make sure students in their tables record the correct units.
10. *[optional for Physical Science and Physics]:* As a summary of the concepts to present, show the attached Power Point® presentation "How much does it cost to use it."

Day two can end here. Student can finish the 4th and 5th columns of the table for homework.

11. Scan and project (or photocopy) an electrical bill. Have students locate the cost per unit, which is kWh. (On many bills, a tiered system and sliding rate scale is used, so figuring out how much one pays per kWh is not that simple! But it is good to know.)
12. Give this formula:

$$\text{Cost} = \text{rate} \times \text{energy, which contains these units:}$$

$$\text{\$} = \text{\$/kWh} \times \text{kWh}$$
13. Students give the second-to-last column the heading **Cost per day**. Now using the above, as guided practice, students calculate the cost per day or the first several items. Then later complete the entire column.
14. Students also complete the **Cost per year** column, by multiplying cost per day by 365.

15. When the tables are completed, below the table have students write their own conclusions on wise usage of electricity.
16. Recall the law of conservation of energy, that energy is always conserved, but may easily change forms. Electrical energy may be changed for us into work. But what happens to the rest, if it cannot just disappear. Show a VCR or TV that has been left on for an hour. Have a student place her hand on the top. It should be noticeable warm. That heat is wasted energy. All Electrical appliances make some heat. A refrigerator makes more heat than it does coolness! It is most efficient to use appliances that generate the minimum heat, because heat is wasted energy, unless of course that the machine is intended to be a heater.

17. Show students an example of the ENERGY STAR® symbol. Note that for equivalent items like refrigerators and televisions, the ones that have this rating and symbol do the same job for less energy. It makes sense to look for this symbol.



18. It is very important to note now that the energy ratings on the labels of appliances are not how much power they actually draw continually, but the maximum that they draw. For example, a refrigerator uses the amount it says only when the compressor is on, a TV only when it is being turned on and at maximum volume, a printer only while it is printing, a heater when it is set to maximum. So our numbers for some items in the table may be too high. This could be true for anything with a dial or that is digital. Better numbers can be obtained with a wattmeter.

19. *Optional with wattmeter.* Measure the actual wattage of some of the items in the table. It will be less to significantly less than the label rating, depending on what the item is doing at the time. The results can be fascinating.
20. Discuss as a class reasons for conserving electrical energy. Students add these to their notes. Reasons may include: saving limited energy resources for future generations, reducing pollution from coal and gas power plants, reducing greenhouse gas emissions, saving money, being a good steward.

Day three can end here. Student can complete table for homework.

21. Class should now be able to calculate the cost to run the lights in this classroom for a school year (180 days). Count the lamps, and give the watts/lamp, and give the hours they are on per day. The answer will amaze you.
22. From our tables, as a class come up with easy targets for conservation. Calculate how much can be saved in a year by taking the above steps. Estimates okay.
- Turn off a TV that is not being watched. Savings per year: \$_____
 - Unplug a TV that will not be used for over a month. Savings per year: \$_____

- Push the off button on computer printer after printing. (Most turn themselves on automatically when given the command to print, but do not turn themselves back off). Savings per year: \$_____
- Turn off a light (e.g., porch light) that is left on needlessly. Savings per year: \$_____
- Reduce classroom room lights to half on. Savings per year: \$_____
- Set a computer monitor to energy savings mode (right click on desktop, properties, screen saver, energy savings properties). The monitor uses about 2/3 of the energy of the computer. Savings per year: \$_____

Note that schools and industries pay a higher rate than the \$/kWh shown on your residential bill.

23. Summary homework assignment: Students make an energy inventory of their own homes, after the pattern of the table made in class, and add to their own recommendations for electrical energy conservation and an estimate as to how much money can be saved per year.

FOLLOW-UP & ASSESSMENT

1. *Optional research assignment:* Students go on line to sce.com and summarize recommendation for residential users to conserve electrical energy.
2. Include these concepts on a quiz:
 - Defining energy
 - Defining power
 - Formula for calculating electrical energy.
 - Appropriate units for power and energy



3. Give students problems like the ones done on their table:
 - calculating kilowatts from watts
 - calculating electrical energy in kWh
 - calculating electrical cost
4. Pick the biggest power users from a given list
5. Written assessment: *My reasons to conserve electrical energy are....*

Watt Does it Cost to Use It?

Name _____

Period _____

Item	Power needs	Big Users (>200 W)	On > 1 hour/day	Hours left on/day	Energy/day	Cost per day	Cost per year
incandescent lamp							
fluorescent lamp							
egg beater							
space heater							
VCR							
hair dryer							
CD player							
clock							
computer printer							
cell phone charger							
TV							
toaster							

Conclusions: