# What's The Cheapest Watt?

## Instructor's Guide & Answer Key

**Objectives:**

- Students will survey and measure the energy demand and use of common electrical appliances.
- Students will understand energy use issues and problems faced by home appliance users.
- Students will summarize and report on their research.
- Students will analyze class research to prioritize and recommend energy savings.
- Students will know the consequences of using energy efficient home appliances in terms of:
    - electricity saved
    - money saved
    - energy resources saved
    - air pollution saved
- Students will consider methods of energy conservation, including the use of efficient appliances.

**The Main Thing:**

**What's The Cheapest Watt?** emphasizes many important concepts. Among the most important:

- In order to make smart decisions about energy and its conservation, good, objective data about energy use must be acquired and analyzed.
- Energy conservation saves money, preserves natural resources and saves on air emissions, which students will see (and calculate) in this lesson.
- Conserving energy reduces the energy load of a home or building. This is almost always the first, best, and most important step to be taken before installing any renewable energy technology.

The natural strength of this lesson is that students take energy consumption measurements from electrical appliances they actually use and evaluate their use with an eye to energy conservation. The thinking needed—proper measurement, making estimates, considering cost, etc.—is just the kind of thinking required to truly understand energy conservation. In a small, but very real way, students act as energy auditors.

By the end of this activity, students will know **What's The Cheapest Watt?**—the watt that costs the least, uses the fewest resources, and causes the least pollution. *It is the watt we never use*. *The watt we never use* is even cheaper and more effective in every important and measurable way than any watt of electricity produced by renewable energies.

**Activity and Teacher Notes:**

In this activity, students will take energy measurements from electrical appliances they actually use, analyze those measurements, and draw important conclusions about energy conservation. How this is carried out is open to you, and probably depends on the level of your class, the depth you want to go, and the number of **Kill-A-Watt®** energy use measurement units you have available to you.

It is hoped you have enough Kill-A-Watts that you can sign one out to every student in your class over a series of days so that all students can be intimately involved in the activity. The activity is loosely written to be done this way. Using this approach with 6 Kill-A-Watts, it is recommended that you group students to introduce the activity (in a class of 24, six groups of four). Each member of the group could then use a Kill-A-Watt at home over the next several days to survey 24 different electrical appliances. After that, class data could be pooled, and the activity could be concluded. During the days students use the Kill-A-Watt at home, other activities could be pursued. But those several days would give you the opportunity to discuss questions that will probably arise about how to use the Kill-A-Watt, and to perform necessary calculations.

Alternately, you could group the class, decide on 6 appliances to be surveyed, and assign one to each group. Then ask one student from the group to use the Kill-A-Watt at home to survey that appliance. Another approach would be to have 6 commonly used appliances available to students to survey in the classroom. Using this approach, students could "adopt" one appliance, survey it, and share data with the class on it, or students could rotate through all 6 appliances. Other approaches to this activity are surely possible. It is assumed that you have at least a few Kill-A-Watts available to you to perform this classroom activity.

Regardless of the approach you take, this activity requires good teacher leadership and communication. If you choose a group approach to the activity, it is still expected that each student individually complete the written exercises.

This activity has been written around the **Kill-A-Watt P4400** because of its low cost and versatility. Other electric consumption monitors could be used to perform the activity with only minor adjustments to what is written here. Note that the Kill-A-Watt P4400 only works with standard 120 Volt, plug-in appliances.

In the end, you will have to determine the procedure you want students to follow and communicate it to them. You should work with a Kill-A-Watt enough to be comfortable using it in almost any normal situation, can direct students in how to use it, and can answer their questions about it. Take advantage of your potential to edit this lesson by:

- adding more specific written procedures for your students to follow if you believe they are needed.

- adding questions to, and deleting questions from, the activity to suit the level of your students and the depth you want to pursue the topic.

**Introduction:**

You may center your introduction on the lesson Introduction as it is written or develop your own. In any case, points that need to be brought out at the beginning are:

- students will be surveying appliances they typically use with a device called a Kill-A-Watt.

- every watt of electricity that is used has consequences (in cost, resources, and emissions).

- by the end of the activity, students will be able to identify which kind of watt has the fewest of these consequences.

The lesson is written for you to use page two of the **Student Lesson and Response Guide** to have your class to list as many electrical appliances they use as possible. This will give you opportunities for discussion about the number of electrical appliances students need and use, how much they are taken for granted, and the cost, resource, and emissions consequences of their use. This list can then be used to assign appliances for students to survey, assigning them based on how you've decided to structure the lesson.

**My Appliance:**

Once appliance assignments have been made, you might ask students to take a moment to make an intuitive or uneducated guess at which appliances they think will use the most electricity over the course of one year. Soon they will acquire data that will enable them to turn their guesses into facts.

You will certainly have to demonstrate how to use the Kill-A-Watt unit, which is why you should take time to become familiar with it. Where students are likely to have trouble is determining how to calculate annual electrical use when surveying appliances they can sample for only very short periods of time. This can be especially tricky in situations where an appliance cycles on and off on its own, or when the appliance is used intermittently. How to deal with these situations can lead to very fruitful discussions of how to deal with assumptions, how to collect "good" data, and how to conserve energy.

Since students will be required to collect this data, this is a good time to discuss, and then define electric power demand vs. electrical energy use. The difference between these two is not always easy for students to understand. This is also a good time to discuss and define phantom load. Here are our definitions, which students can write into question #2 of their handout:

**Electrical power demand:** *The quantity of electric power that an appliance is drawing at any given instant, measured in watts (W) or kilowatts (KW)*. <u>There will never be a unit of time</u>.

[When turned on, a 100 watt light bulb is drawing, or using, 100 watts of electrical power (which is also equal to 0.1 kilowatts, or 0.1 KW) at any given instant.]

**Electrical energy use:** *The quantity of electrical power that an appliance uses over time, measured in KWH (kilowatt-hours)*. <u>There will always be a unit of time</u>.

[When turned on for <u>ten</u> hours, a 100 watt light bulb will use 1.0 KWH of electrical energy. (A 100 watt light bulb is the same as a 0.1 kilowatt light bulb. Leave it on for ten hours and its use is 0.1 kilowatts x 10 hours = 1.0 kilowatt-hours, or 1.0 KWH).]

**Phantom load:** Sometimes called "vampire load," this is *the electricity used by an appliance that is plugged in but turned off* (sometimes called "on standby"). Phantom load may be talked about in units of demand, or watts. But to quantify its cost, it must either be surveyed in, or converted to, our unit of use, the KWH.

It is strongly recommended that you demonstrate the use of a Kill-A-Watt by plugging actual appliances into it, going over its basic functions, and then showing how to collect electrical demand and electrical use data. It would be especially instructive to use the Kill-A-Watt first with an appliance that is pretty straightforward to use (like a fan). After that, demonstrate with an appliance that cycles on and off, and an appliance that draws a phantom load. Encourage discussion about how to estimate annual use from a small sample of data.

You might consider generating especially fruitful discussion at this early time by demonstrating the use of the Kill-A-Watt with an incandescent light bulb, then a CFL, then LED, all of the same (or similar) level of illumination. This will clue students into the idea that different appliances can accomplish the same task with different levels of electrical consumption—something you may ask them to research later as part of this lesson. You will soon find your classroom wrapped up in a discussion about efficiency, cost, cost recovery, and appliance quality. Discussions like these are real in many homes and businesses across the world.

As you demonstrate with the Kill-A-Watt, it would be helpful for you to visually model how students might take a small sample of survey data and mathematically estimate total electricity <u>used</u> over the course of the year. This can be tricky, because each appliance is different (leaf blower vs. cell phone charger vs. basement freezer) and people use appliances differently. But this is a good exercise in getting students to carefully estimate from a small sample of data, and to think carefully about how they use appliances that they typically take for granted.

In the end, students must estimate electrical <u>use</u> for their appliance for a year. There are many ways to accomplish this. Following are a couple of classroom examples you might use.

**Example 1: Annual microwave electrical use narrative and model:**

In talking with family members, we determined that we use the microwave, on average, about 20 minutes a day, every day. During those 20 minutes, the microwave draws an average of 1200 watts. Therefore, its daily electrical use is 1.200 kilowatts x .333 hours = 0.4 KWH. There are about three weeks during the year when no one is in the house (usually because of vacation). So we use the microwave 365 – 21 = 344 days of the year. Take 344 days of use x 0.4 KWH used / day and you get an annual electrical use of 137.6 KWH.

*[This is probably a harder method for arriving at appliance electrical use for a year. In this example, the student measured watts of use when the appliance was being used, and then worked the time component into the calculation to get KW<u>H</u>. Also note that by calculating electrical use this way, phantom load is not taken into account. The next example is probably the better, more common way to estimate appliance electrical use.]*

**Example 2: Annual dehumidifier electrical use narrative and model:**

Our family uses a dehumidifier in the basement from May through October—half of the year (183 days). It cycles on and off on its own, depending on the humidity in the basement. During the off cycles, it is on standby and draws a phantom load. To estimate electrical use for the year, I measured the KWH used by the dehumidifier in a 24 hour period—one day. It used 7.2 KWH. Take 183 days of use x 7.2 KWH used / day and you get an annual electrical use of 1317.6 KWH.

*[This is probably the best way to estimate appliance electrical use for a year—plug the appliance into the Kill-A-Watt for 24 hours (or longer) and record the KWH used for a day (or several days). As long as the use of the appliance is typical for that day, a yearly estimate will probably be pretty good. Here is another place to develop good discussion. Does daily use of an appliance vary by season? By the number of people in the house? By the individual personal preference of the person using the appliance Other factors?]*

Reviewing examples like these should help your students "game plan" how to survey their assigned appliance and write their answer to question #3. You should review the **My Appliance Information and Estimates** questions with students, to answer any questions they may have in advance.

**Steps To Take Before Killing Your Kill-A-Watt:**

Invariably, there is time between the introduction and the time when students finish acquiring data with their Kill-A-Watt. This section was specifically written as a reference for your to students to consult as they finish using the Kill-A-Watt so they make no mistakes with it at that important time. Review this section with your students, and remind them to use it before unplugging their appliance from the Kill-A-Watt.

**My Appliance Information and Estimates:**

Some of this section may be completed before students unplug. But once unplugged, students should complete this section right away.

Once students have established the annual use for their appliance in KWH, determining annual cost, coal burned, and air emissions in using the appliance is pretty easy to do through straightforward multiplication.

The cost of electricity, item #12, will have to be filled in. Try to provide your students with the current cost in their electrical service area. This cost can be found on most typical residential energy bills. Students will probably not know it, so you will probably have to give it to them. Given in the activity is a nationwide average, current at the time of this writing.

Current and accurate coal burned / KWH (#13) and air emissions released / KWH (#14) are found through student research. Directions for getting this information are found in the student lesson. You should do this research in advance to make sure students are finding and using the right numbers in their lesson. Alternatively, you may do this research together at the same time in class. If you choose this option, you may wish to review the EPA Equivalencies Calculator with your class. There are many avenues for discussion and learning to be found just within this website.

**Lesson Summary Questions:**

Once all students have completed surveying their appliance it is time to summarize and conclude the lesson. It makes sense to make available some kind of visual aid where data on each appliance can be posted (blackboard, whiteboard, shared spreadsheet that can be projected, etc.). All appliances surveyed can then be easily compared.

Example:

| Appliance<br><br>Energy Star? | Electrical Demand (Watts) | Annual Use (KWH) | Annual Cost ($) | Annual Coal Burned (Lbs.) | Annual Emissions Released (Lbs.) |
|---|---|---|---|---|---|
| 1. yes no | | | | | |
| 2. yes no | | | | | |

Once complete, share this list with your students digitally. They will need to insert it into their document for question #16.

Good success for the lesson now depends on good discussion, and much of it can be centered on the student questions in the activity. You may want to have students complete their answers to the Summary Questions with you in class with you during discussion. Structure the questions, discussions, and answers any way you like, but the following thoughts and points should be developed:

- Ask students—maybe each and every student—to comment on how they could save energy in the use of the appliance they surveyed (Summary Question #12). This is one of the important learning outcomes of the activity and good discussion should result from this!

- From question #18: Having taken the time to “audit” their own appliance, students should now be a lot more familiar with how different appliances work, and how they are used. They should be able to make very good recommendations on how to conserve energy in the use of appliances. Be sure to make this connection though, one that every energy auditor has to pay attention to—students should definitely apply conservation thinking to the appliances from their list that use the most energy. Conserving energy with appliances that are the biggest users almost always provides the greatest energy savings.

- From question #19: Electricity is a secondary source of electricity. Coal, natural gas, uranium, the sun, and others, are primary energy resources used to generate electricity. All primary sources for our region should be listed by students in their answers to question #16, along with their percent of generation. This is accomplished using the USEPS Power Profiler as described in #16 of the Student Guide for the activity. Review this on your own before doing this activity.

- From question #20: This is a very key question. Students should be able to tell you the answer. When they conserve energy, they save money, save natural resources (like coal), and save emissions from being released to the air.

- From question #21: **What’s The Cheapest Watt?**—the kind of watt that costs the least, uses the fewest resources, and causes the least pollution? If your students haven’t figured this out by now, you might want to keep them after school until they do. The cheapest watt—the watt that costs the least, uses the fewest resources, and causes the least pollution—is the watt they never use.

- From question #22: Conserving energy reduces the energy load of a home or building. This almost always costs the least in dollars, resources, and pollution than the application of any renewable energy technology. An added benefit? Once energy loads have been minimized, the size of a renewable energy system that’s applied can also be minimized. In turn it costs less in dollars, resources, and pollution to the environment to make and install your renewable energy system.

Students should now be ready to submit a meaningful, well-completed **What’s The Cheapest Watt?** activity to you for an excellent grade!