HOME ENERGY AUDIT: ELECTRICITY USE

TEACHER LAB TEMPLATE

Dean Goodwin
Director of Environmental Education
Kimball Union Academy
Meriden, New Hampshire

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Objectives

This activity allows your students to:

- Conduct an energy audit/survey of electrical appliances at their homes, in terms of the energy used and the costs involved
- Determine the amount of energy used by different appliances
- Interpret a monthly electric bill
- Make calculations and conversions relating to energy use
- Increase their understanding of energy units such as watts, volts, amps, and kilowatt-hours
- Evaluate the relationship of electricity generation and use to environmental consequences
- Design and implement a specific strategy or conservation plan that will lead not only to a reduction in the amount of electricity used but also a lower monthly cost

Why Use This Lab in the APES Course?

Many students do not realize the importance of electricity in their lives until they experience a power outage. This lab fosters an understanding of how conservation of home electricity use in their homes can have a positive impact on the environment. The lab activity provides a useful link between energy topics and environmental consequences, for example, global warming resulting from carbon dioxide release from coal-burning power plants. How energy conservation in their own homes could lead to a potential reduction in greenhouse gas emissions, and hence global warming, is an empowering concept for the students to grasp. The more links we can provide students in terms of needs of society versus environmental impact, the better prepared they will be as citizens of tomorrow. The lab activity covers an important section of the APES curriculum, as described below.

Correlation to Topic Outline in Course Description

I. A. The Flow of Energy

1. forms and quality of energy
2. energy units and measurements

III. E. Energy

1. conventional sources
2. alternative sources

V. B. Higher-Order Interactions (consequences)

1. atmosphere: global warming

VI. E. Issues and Options (conservation)

Correlation to National Science Education Standards

Principles:

- Science is for all students.
- Learning science is an active process.

Teaching Standard A:

Teachers of science plan an inquiry-based science program for their students. In doing this, teachers

- Select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students.

Teaching Standard B:

Teachers of science guide and facilitate learning. In doing this, teachers

- Focus and support inquiries while interacting with students
- Orchestrate discourse among students about scientific ideas
- Challenge students to accept and share responsibility for their own learning
- Encourage and model the skills of scientific inquiry, as well as the curiosity, openness to new ideas and data, and skepticism that characterize science

Teaching Standard C:

Teachers of science engage in ongoing assessment of their teaching and of student learning. In doing this, teachers

- Guide students in self-assessment

Teaching Standard D:

Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science. In doing this, teachers

- Structure the time available so that students are able to engage in extended investigations

- Create a setting for student work that is flexible and supportive of scientific inquiry
- Ensure a safe working environment
- Identify and use resources outside the school

Teaching Standard E:

Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning. In doing this, teachers

- Display and demand respect for the diverse ideas, skills, and experiences of all students
- Enable students to have a significant voice in decisions about the content and context of their work and require students to take responsibility for the learning of all members of the community
- Nurture collaboration among students
- Model and emphasize the skills, attitudes, and values of scientific inquiry

Assessment Standard A:

Assessment must be consistent with the decisions they are designed to perform.

- Assessments are deliberately designed
- Assessments have explicitly stated purposes

Assessment Standard C:

The technical quality of the data collected is well matched to the decisions and actions taken on the basis of their interpretation.

- The feature that is claimed to be measured is actually measured
- Assessment tasks are authentic
- Students have adequate opportunity to demonstrate their achievements

Unifying Concepts and Processes:

Standard: As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes:

- Systems, order, and organization
- Evidence, models, and explanation
- Constancy, change, and measurement

Science As Inquiry:

Content Standard A: As a result of activities in grades 9-12, all students should develop

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Science As Technology:

Content Standard E: As a result of activities in grades 9-12, all students should develop

- Understandings about science and technology

Science in Personal and Social Perspectives:

Content Standard F: As a result of activities in grades 9-12, all students should develop understanding of

- Natural resources
- Environmental quality
- Science and technology in local, national, and global challenges

Introduction

Measuring Home Electricity Use

In this lab activity, the teacher is providing the opportunity for students to determine for themselves how they would go about measuring the amount of electricity that is used in their own homes. Rather than the teacher simply giving them a set procedure, students have to figure it out for themselves. The teacher can help guide the students in their research and facilitate the discussion from the student brainstorming session. For example, students could use the Internet and/or contact the local utility company to arrive at a procedure to monitor home electricity usage.

Generally, the students offer the following suggestions:

1. Analyze the monthly electric bill.
2. Look at the tags on the electric appliances to determine the energy use.
3. Monitor the electric meter at their house.
4. Use a special instrument to analyze electric appliances.

Allow each student or student group to decide which method they wish to use. As they begin to take measurements, they may uncover limitations or difficulties in using their method of choice. One of the hardest things a teacher has to do during this process is to take on the role of facilitator and refrain from giving too many directed instructions to students! Allowing them to learn for themselves through a critical-thinking process and self-evaluation enhances the educational experience! Once the data has been obtained, students can analyze it and come up with a conservation plan for their homes and also equate their electricity use to carbon dioxide emission. (The latter exercise assumes that their electricity has been produced from a coal-burning power plant.)

Analysis of the monthly electric bill

Analyzing the monthly electric bill will provide information as to the *total* kWh used in the household by all electrical appliances, but *will not* give data as to the energy requirements of *individual* electric appliances. Students could use the data from their monthly bills to track the amount of electricity used over the past year. A home energy conservation plan can still be suggested, and students can determine how much carbon dioxide (per kWh) has been emitted on a monthly basis from the whole household. There are other interesting entries on electricity bills that can be discussed with the class; for example, distribution charge, transmission charge, and generation charge are three of the services listed on my electricity bill. Such details would be present on bills in other parts of the country.

Looking at the tags on the electric appliances to determine the energy use

Some students may recall that many electric appliances have a label or tag on them that gives several pieces of information. In most cases, the voltage and current is noted. Given this data, students can determine the number of watts the appliance uses for each hour of operation from the simple formula described in Appendix I. By listing all of the electrical devices in the home and the wattage rating of each, students can record, over a certain time period, how long each device is used. This could be done for one day during the week and over the weekend to get an average use per day, week, or month. They could compare their findings to the monthly electric bill and note any differences. A home energy conservation plan and carbon dioxide emission can be assessed from the results. A typical student worksheet for this procedure is shown in Appendix II.

It should be noted that the formula given in Appendix I ($W = V \times I$) is true for all direct current or DC applications. However, when applying this formula to alternating or AC applications, such as in the home, it is true only for pure resistance loads such as an electric stove or an incandescent light. To be completely correct when using this formula for nonresistive loads, a correction is used called the power factor (f). So the formula would become $W = V \times I \times f$ when applied to AC calculations. This consideration does not make serious errors in the student calculations in their home energy audit, and the power factor is ignored in these calculations. The teacher should be aware of this in case a student who is well versed in the application of alternating current, from physics or other classes, brings it up in class discussion. For the purposes of the calculations in this environmental science activity, the formula $W = V \times I$ is used.

Monitoring the electric meter at their house

Some students may come up with this procedure, which is a little more complex to do but nevertheless can provide some good data for them to analyze. A good description of how to measure power at home without special tools, using the outside electric meter, can be found at http://staff.washington.edu/corey/power.html. A home energy conservation plan and carbon dioxide emission can be assessed from the results.

By observing the number of rotations of the rotor disk in the outside electric meter, while alternatively switching electric appliances off and on, is also described in the publication Science Teachers Instant Lab Kit, on page 37. The data obtained from this procedure is not as complete or as quantitative as that obtained by the procedure described at http://staff.washington.edu/corey/power.html, but it does give an indication as to which appliances use the most power.

Using a special instrument to analyze electric appliances

There are a number of power meters that can either be made or be purchased that students can use to monitor the energy use of individual household appliances. Such devices can give the most accurate results for an investigation such as this. Students could be allowed to take the unit home, or it could be used on appliances in the classroom as a demonstration tool. A home energy conservation plan and carbon dioxide emission can be assessed from the results. An example of student data obtained using the Watts Up? Electricity Meter is shown in Appendix III.

Designing an Energy Conservation Plan

After students have collected their data, they can spend time designing a conservation plan specific to their homes. The plans should be feasible and easy to implement by the households. It is a good idea to get parents involved in this lab activity, as it has the potential to decrease the monthly electric bill! There are many resources relating to energy conservation that students could evaluate in order to determine what would work best for their own homes. For example, see Section 19.4 of the publication Environmental Science Activities Kit. Some students may describe different strategies for winter and summer. It is a good idea to have students explain the pros and cons of each of their suggestions. The local utility company is often very pleased to provide ideas for saving energy and may even send a speaker to come to the class! Some companies even go so far as to conduct energy audits for households upon request and may even take infrared photographs to assess heat loss.

Linking Electricity Use to Carbon Dioxide Emission

This part of the lab activity serves to raise the level of awareness that each time we turn on a light, we may be making a contribution to global warming, particularly if the electricity we use is generated from a coal-burning power plant. By performing some simple calculations, the students' data can be evaluated in terms of the number of pounds of carbon dioxide that is produced from their homes and the volume that this corresponds to. It can be easily visualized in terms of refrigerators full of carbon dioxide! This analysis also helps students to link energy use to global atmospheric change. An explanation of the calculations is provided in Appendix IV.

Group Size

This lab is very flexible in terms of student numbers. Individual students can perform it in their own homes. It also works well if students want to work in pairs or small groups, as some of the measurements are easier to make with a partner. Also, each student or pair of students could collect the data and then work in larger groups (of three or four) to analyze the results and make their presentations. The amount of time the teacher can set aside for this activity will determine the student group size that is used.

Lab Length

This activity requires one or two periods to introduce the topic, conduct research, and brainstorm ideas regarding collection of the data. Students can collect data on their own time, perhaps over the weekend or during the week, or during lab periods if they are using an instrument to measure the wattage consumption of electrical appliances that they bring into class. Electrical measuring instruments can also be lent out to students to take home on a nightly basis. After the data has been collected and analyzed, several class periods should be set aside for student presentations.

Preparation and Prep Time

The main time commitment is getting resource materials ready to distribute to the class. These materials will guide students in the method(s) available to them to collect data. The method they/you choose will determine the amount of time needed. For example, if you decide to personally make a unit to measure wattage, then it will take longer than ordering a ready-to-use model that can be plugged in straight out of the box! You should contact the local utility company before the students carry out the lab activity. This allows you to obtain some of the information for yourself and to alert the company that students will be contacting them as part of their research investigation.

Materials/Equipment

Students should have easy access to a wide variety of electrical appliances in their homes. They may need a watch or stopwatch if electing to perform measurements using the electric meters on the outside of their houses. Students should be encouraged to work out the mathematical computations without the use of a calculator; they could check their work with a calculator afterwards. (Remember, calculators are not allowed on the APES Examination, and as the calculations are fairly simple, this would be good practice for the exam!)

Students can conduct this lab activity with a minimal amount of equipment and at virtually no cost. Good data can be obtained from the tags on appliances or by monitoring the rotor disc on their outdoor electric meter.

Some teachers may wish to build or purchase meters to use in this lab activity.

Suppliers

For teachers who want to make their own power meters, guidelines on how to make a simple power meter can be found at:

http://www.silentpcreview.com/modules.php?op=modload&name=Sections&file=index&req=viewarticle&artid=19

For teachers who wish to buy ready-to-use units, these can be purchased at a reasonable cost. A very good instrument for measuring electricity use of any 120-volt device is the Watts Up? Electricity Meter, available from:

Electronic Educational Devices, Inc.
2345 S. Lincoln St.
Denver, CO 80210
Call: (877) 928-8701
www.doubleed.com/secure.html

The unit can measure a number of different parameters including cumulative cost, instantaneous wattage, cumulative time, and cumulative kilowatt-hours. The unit also comes with a basic curriculum module that gives suggestions for a number of different exercises that the unit can be used for. The base model is around $100, and an updated pro-model for around $140 is now available that can be linked to a computer for downloading the data and producing graphical representations of the results. I would suggest purchasing the latest pro-model version and link it to a computer. It works very well for classroom demonstrations, and discounts are given for class sets of the units.

Another unit that does not have as many features as the Watts Up? Electricity Meter, but can keep track of kilowatt-hours used, is the Kill A Watt Meter, available for around $50 from:

http://www.ccrane.com/science_instrument_index.asp

Safety and Disposal

Students should be reminded about the potential dangers of using electricity. They should be careful when handling any electrical device. Students need to unplug any electrical appliance before examining them for the label or tag that provides information as to the voltage, current, and wattage rating.

Teaching Tips

After being presented with the task in hand, students brainstorm such questions as “What do we know?” “What do we need to know?” and “How do we find out what we need to know?” These can be given as homework or as in-class assignments. Students share their answers with each other and work together generating ideas about how to measure the electric use in their homes through open discussions facilitated by the teacher. Students can be assigned onto a research team in order to find out the answers to the questions they have raised. Research can be performed on the Internet or by contacting the local electric utility company. Students can call or e-mail any organization that they feel may be able to provide them with information. Some teachers may find it useful to assist the students, at appropriate times, by facilitation of concept-mapping strategies on the board. This may help students to visualize the different methods for measuring electricity that they are coming up with, before deciding on the method that they will use in their own assessment.

Both class and homework times are utilized for the completion of this lab activity. Students teach each other about their findings in their particular research area. The time taken for this project depends on the teacher and the depth of coverage. I also set the students assignments to discuss the issue with family members and report feedback to the class. During this student-centered approach, the teacher acts more as a facilitator and guides the class through the process. Students actively participate in presenting their research findings to the class.

The teacher can also have the class carry out mathematical conversions of their data from kWh into BTUs. There have been a number of free-response questions on the APES Exam that relate to energy conversions/calculations, which could also be assigned to the class.

This lab activity does not take into account the phantom loads that electrical items draw when they are plugged in but switched off. Students often bring up this topic for discussion as the lab progresses. Some good math questions relating to this topic can be found in the publication Environmental Issues: Measuring, Analyzing, and Evaluating.

The lab activity assesses only the electrical energy that is used in the home. Some students may wish to take this study further and look at other energy demands, such as the family consumption of gasoline or fuel oil/natural gas to heat the house. This may come up during the students’ design of an energy conservation plan, as many do not just want to stop at electricity use but take a wider view of how they can save even more energy in the home! For those students, it may be interesting to have the carbon dioxide emission values from other fuels or travel modes.

1.5 lb of CO_2 per kWh of electricity generated from a coal-burning power plant

22 lb of CO_2 per gallon of fuel oil

11 lb of CO_2 per therm of natural gas

20 lb of CO_2 per gallon of propane or bottled gas

22 lb of CO_2 per gallon of gasoline

0.9 lb of CO_2 per mile of air travel

0.6 lb of CO_2 per mile of rail or subway travel

0.2 lb of CO_2 per mile of inner-city bus travel

In addition to linking energy use and production to carbon dioxide emissions and global climate change, other atmospheric consequences such as acid precipitation, ground level ozone buildup, and smog formation can also be mentioned. Invariably, these topics come up during student discussions, which provide a good opportunity for the teacher to help the students make more connections between energy use and atmospheric effects.

Another interesting investigation that some students may wish to pursue is to research facts regarding the electricity delivery (or grid) system, in order to fully appreciate exactly just what happens when they turn on a light switch!

Allow the students as much flexibility as possible in how they analyze and present their results to the class. Students often use PowerPoint or posters to supplement their talks.

Possible Assessments

Tasks that were given as homework can be checked as part of the student's ongoing homework grade for the class. A student's performance on the lab activity can also be assessed using any of the following parameters:

- Discussion, in-class participation, written assignments, research data, oral presentations, and the lab report; test and quizzes on the material
- Individual scores for each student's research portfolio, and a group or individual grade for the class presentation
- Quizzes on, for example, information from the student presentations, any student-produced handouts, data from the lab activity, and any facts presented from research

When performing inquiry-based units with the students, it is important that they are made aware beforehand of how the teacher will be evaluating their work. Generally, my students receive a grade for their lab report, which includes their conservation plan and carbon dioxide data, and a grade for their class presentation. Another outcome for the class as a whole could be to organize an energy awareness campaign in the school or to produce informative posters to display in the buildings.

Sample Rubric for Assessment

I use a checklist for evaluating discussions and oral reports. All members of the class, including the teacher, complete this form. In this way, students evaluate each other's performance and learn what constitutes effective communication. A sample rubric is given below. Appendix V gives hints for making a good presentation, and Appendix VI provides copies of the scoring rubric.

ORAL REPORT EVALUATION

Presenter's Name: ______________________________

Title of Report: ______________________________

Student shows:	Low				High
1. knowledge of subject	1	2	3	4	5
2. good voice projection	1	2	3	4	5
3. good eye contact	1	2	3	4	5
4. good use of visual aids	1	2	3	4	5
5. creativity and enthusiasm	1	2	3	4	5
6. ability to remain focused	1	2	3	4	5
7. good response to questioning	1	2	3	4	5
8. evidence of thorough research	1	2	3	4	5
9. ability to present the material clearly	1	2	3	4	5
10. ability to summarize all views on the topic	1	2	3	4	5

Evaluator's Name: ____________________________ **Total Score**: __________

References/Resources

Three good software programs could be used in conjunction with this lab activity:

Environmental Science: Field Laboratory (Falcon Software, Inc.)
http://www.falconsoftware.com/

Home Energy Audit (EME Corporation)
http://www.emescience.com/

Focus on the Environment (EME Corporation)
http://www.emescience.com/

An excellent video that relates energy production to atmospheric change is:
What's Up with the Weather (NOVA/Frontline, WGBH Boston, 2000)

An article entitled "Your Contribution to Global Warming," by George Barnwell, appeared in the February-March 1990 issue of National Wildlife, the magazine of the National Wildlife Federation. The article describes the amounts of carbon dioxide that are emitted from everyday electric appliances, and it is a good resource. Check your library archives for a copy or contact the National Wildlife Federation.

Some useful Web sites are:

General interest

www.ccap.org/ (Center for Clean Air Policy)
http://cdiac.esd.ornl.gov/pns/faq.html (Carbon Dioxide Information Analysis Center)
www.eia.doe.gov/ (Energy Information Administration)
www.energy.gov/ (Department of Energy)
www.epa.gov/ (Environmental Protection Agency)
www.energynet.net/ (EnergyNet Community Web)
http://eelink.net (Environmental Education Resources)
www.enviroliteracy.org/index.php (The Environmental Literacy Council)
www.exploratorium.edu/climate/ (Global Climate Change Research)
http://www.need.org/ (The National Energy Education Development Project)
www.ncar.ucar.edu/ncar/ (National Center for Atmospheric Research)
www.rmi.org/ (Rocky Mountain Institute)
www.wri.org (World Resources Institute)
www.worldwatch.org/ (Worldwatch Institute)

Basic facts about electricity
http://cipco.apogee.net/foe/home.asp

Carbon dioxide calculators
http://www.gdrc.org/uem/co2-cal/co2-calculator.html
http://www3.iclei.org/co2/co2calc.htm
http://www.accc.ca/energyefficiency/actions/calculator.htm (Canada)
http://www.natenergy.org.uk/convert.htm (United Kingdom)

Calculating your carbon footprint
http://www.safeclimate.net/individual.php or
http://www.wri.org/press/safeclimate.html

Calculate the energy savings and carbon dioxide emissions by switching to solar water heating
www.ieatask24.org/CO2.html

Examples of student-directed labs relating to electricity, energy, calculations, and conservation can be found in the following books:

Enger, Eldon D. and Bradley F. Smith. *Field and Laboratory Activities in Environmental Science*, 6th ed. New York: McGraw Hill, 1997.

Fleming, Michael. *Science Teachers Instant Lab Kits*. West Nyack, New York: The Center for Applied Research on Education, 1991.

McConnell, Robert L. and Daniel C. Abel. *Environmental Issues: Measuring, Analyzing, and Evaluating*, 2nd ed. Upper Saddle River, New Jersey: Prentice Hall, 2002.

Roa, Michael L. *Environmental Science Activities Kit*. West Nyack, New York: The Center for Applied Research on Education, 2002.

Walker, Pam and Elaine Wood. *Hands-On General Science Activities with Real-Life Applications*. West Nyack, New York: The Center for Applied Research on Education, 1994.

Wolf, Robert. J., Calvin B. DeWitt, Karen Jankowski, and Gerrit VanDyke. *Environmental Science in Action*. New York, Saunders College Publishing, 1993.

APPENDIX I: Basic Energy Units

Energy Units

The British Thermal Unit (BTU) is a standard energy measure. One BTU is required to raise the temperature of one pound of water by one degree Fahrenheit.

The following approximate conversions give the number of BTUs in a variety of fuels (compiled from references cited in the Teacher Template):

42-gallon barrel of oil	= 5.9×10^6
1 cubic foot of natural gas	= 1,031
1 kWh of electricity	= 3,413
1 ton of coal	= 2.6×10^7
1 gallon of gasoline	= 1.25×10^5
1 gram of 235U fission	= 1.3×10^8
1 gallon of fuel oil	= 1.45×10^5
1 cord of wood	= 2.0×10^7

Note: One calorie is equivalent to 4.0×10^{-3} BTUs
One joule is equivalent to 9.5×10^{-4} BTUs

Basic Electrical Units

Electrical current (I) is the flow of electrons through a wire and is measured in amperes (or amp). The voltage (V) is a measure of the electric force required to keep the electricity flowing through a wire. Electric power, the rate at which electricity does work or provides energy, is measured in watts (W). The current and voltage are related to electric power by the following equation:

$$\text{Power} = \text{Voltage} \times \text{Current}$$

or

$$\text{Watts} = \text{Volts} \times \text{Amps}$$

or simply

$$W = V \times I$$

Large amounts of electric power are measured in kilowatts (kW), where one kW is 1,000 watts. Different appliances have different power ratings, depending on the amount of electricity needed to run the appliance.

Your electric bill reflects the total amount of electrical energy (expressed in kilowatt-hours, kWh) used by all of the appliances in your home for the duration of the time (in hours, h) they were being used. That is:

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

or

$$\text{kWh} = (W \times h)/1000$$

The local utility company charges a certain rate for each kWh of energy used in the home each month. This is reflected in your monthly electric bill.

APPENDIX II: Typical Student Worksheet

Name: ______________________________

Type of Dwelling: (single-family home, apartment, condominium, etc.) ________________

Number of Occupants: ________

Procedure for Monitoring Electric Appliances

1. Carefully unplug the appliance.
2. Locate the information tag.
3. Record the watt rating of the appliance. You may have to calculate this from the voltage and amp ratings.
4. After you have ascertained and recorded the wattage of each electric item or appliance that you use in the home, you are ready to monitor the amount of use of each. You will need the cooperation of all people in the household in conducting this step!
5. Over a certain time period, say 24 hours, keep a log of all the electric appliances that were used in the house and the amount of time that each one was used for. You may wish to do this for a typical weekday and a typical weekend day. That way you can work out your energy use as a weekly or monthly average.
6. For each appliance, convert the data into the number of kilowatt-hours of energy that each one uses. This can be done using the following formula:

$$\frac{\text{kWh} = (\text{watt rating}) \times (\text{total minutes used}/60)}{1000}$$

7 .From your utility company, or from your electric bill, find out the cost of electricity per kWh for your area. Using the calculated kWh for each appliance as determined in step 6, work out the cost of using that electric item over the given time period.

8. The above data can be referred to in designing a home electric conservation plan and also in determining the carbon dioxide that would be emitted if the electricity were produced by a coal-burning power plant.

A typical results table is shown below.

Electric Appliance or Device	Watt Rating (W)	Time Used (minutes/day)	kWh Used per Day	Cost of Use* (dollars/day)
Microwave	1,450	20	0.48	0.048
35″ Color Television	135	240	0.54	0.054
Others…..				

* Based on a cost of 10 cents per kWh

The table can be modified to represent weekly or monthly use. When setting up your table of results, it may be useful to organize it into different categories of appliances.

For example:

Major Appliances (clothes dryer, dishwasher, freezer, microwave, etc.)
Small Kitchen Appliances (coffeemaker, food processor, toaster, etc.)
General Household Items (computer, printer, fax, vacuum, etc.)
Home Entertainment (DVD player, VCR, television, stereo, radio, etc.)
Lighting (light bulbs, halogen lamps, fluorescent tubes, etc.)
Motors (water pump, furnace, garage door opener, etc.)
Workshop Items (drills, sander, etc.)
Personal Care Items (hair dryer, shaver, sun lamp, etc.)
Heating and Cooling Appliances (air conditioners, fans, heaters for water bed/aquarium, hot water heater, etc.)

Another column can be included in the table to show the amount of carbon dioxide emitted by each appliance, or you could produce a separate chart for this data. These are your results, so be creative in how you wish to communicate them to others!

APPENDIX III: Student Data Obtained Using the Watts Up? Electricity Meter.

A personal computer was evaluated for energy consumption and operating cost. The data was then manipulated to reflect several modes of operation, and the amount of carbon dioxide emitted from each mode of operation was assessed.

Data Table

The table below shows the data for operating each appliance for a time period of one hour at a cost of 10 cents per kWh.

Electric Appliance	kWh Used	Cost (cents)
Computer (CPU) only	0.04	0.4
Computer and screen	0.15	1.5
Screen (monitor) only	0.11	1.1

As 1.5 lb of CO2 is generated per kWh, and 1 lb of CO2 occupies 8.75 cubic feet, the following operating modes can be assessed.

Computer and screen on all the time (24/7!)

Time Period	kWh Used	Cost	CO2 Emitted (lb)	CO2 Emitted (cubic feet)
24 hours	3.6	$ 0.36/day	5.4	47.25
1 week	25.2	$ 2.52/week	37.8	330.75
1 year	1,314	$131.40/year	1,971.0	17,246.25

Computer and screen both on 8 hours a day, 5 days a week (e.g., office use)

Time Period	kWh Used	Cost	CO2 Emitted (lb)	CO2 Emitted (cubic feet)
1 day	1.2	$ 0.12/day	2.16	18.9
1 week	6.0	$ 0.60/week	9.0	78.75
1 year	312.0	$ 31.20/year	468.0	409.50

Computer on 24 hours a day, 7 days a week; screen on 4 hours a day, 7 days a week

Time Period	kWh Used	Cost	CO2 Emitted (lb)	CO2 Emitted (cubic feet)
1 day	1.4	$ 0.14/day	2.1	18.4
1 week	9.8	$ 0.98/week	14.7	128.6
1 year	509.6	$ 50.96/year	764.4	6,688.50

Analysis

The student used the calculations shown in the above tables to convince people to turn off their computers and screens when they were not being used. Not only does it make sense economically but it also helps to reduce carbon dioxide emissions, which is beneficial to the environment.

For example, even if someone kept the computer on all the time (24/7) but only used the screen four hours a day, this would save:

1,314 kWh – 509.6 kWh = 804.4 kWh per year = $80.44 per year = 1,206.6 lb of CO_2 per year = 10,557.75 cubic feet of CO_2 per year = about 603 refrigerators of CO_2 per year!

Obviously, if the computer and screen were only switched on when they were needed, then much greater savings, both economically and environmentally, would be achieved!

APPENDIX IV: How Much Carbon Dioxide Is Emitted from My Home?

First, let's assume that the electricity you use in your home is generated from a coal-burning power plant. (Over half of the electricity used in the U.S. is produced from fossil fuels.) Each electric appliance that you use will be responsible for emitting a certain amount of CO_2 depending on how long that appliance is in use for. You can calculate the number of kilowatt-hours (kWh) that an individual appliance uses, then work out how many pounds of CO_2 emission that corresponds to. Generally, about 1.5 lb CO_2 is emitted per kilowatt-hour (kWh) of electricity consumed. For example, if an appliance uses 3.5 kWh of electrical energy, this would produce an emission of:

$$(3.5 \text{ kWh}) \times (1.5 \text{ lb } CO_2 \text{ per kWh}) = 5.25 \text{ lb } CO_2$$

At room temperature and sea level, every pound of CO_2 occupies 8.75 cubic feet, which is about half the size of a household refrigerator. If you know how many pounds of CO_2 are emitted from the different items in your house, it is possible to estimate the corresponding volume of CO_2. This volume can be visualized in terms of how many refrigerators full of CO_2 that would be! Let's assume that on average, one household refrigerator has a volume of 17.5 cubic feet, which would be equivalent to the emission of 2 lb of CO2! So, using the example above, 5.25 lb of CO_2 would occupy 45.9 cubic feet or around two-and-a-half refrigerators full of CO_2!

Let's put that in perspective. A 100 W light bulb that is on for 24 hours a day, say illuminating a sign in a shop window, would use 2.4 kWh of energy. (This comes from 100 W x 24 h/1000 = 2.4 kWh). That is an emission of 3.6 lb of CO_2 or 31.5 cubic feet, which is 1.8 or nearly two refrigerators of CO_2 each day! Just from one 100 W light bulb!

A household that uses an average of 1,145 kWh per month would be responsible for emitting 1,717.5 lb of CO_2 or 15.028 cubic feet or 859 refrigerators full of CO_2 each month!

Carbon dioxide is a greenhouse gas and, along with other greenhouse gases, has been implicated in bringing about global warming. By designing an energy conservation plan for your home, you will not only be saving money on the cost of electricity but also be helping the planet as well!

So just how much carbon dioxide is your household emitting? Work it out! Your home energy conservation plan will reduce it!

APPENDIX V: Presentation of Results

Each student or student group will give a short oral presentation of their findings. It should be no more than 10 minutes long. You can use a format of your choice, including posters, PowerPoint, overhead transparencies, and handouts. You will have a few minutes at the end of each presentation to answer questions from the class. During the talk, the other students in the class will take notes that will be used later on a quiz from the materials presented. This will also help each student to think of questions to ask. After each presentation, every member of the class, including myself, will fill out an evaluation report. Your grade for the oral presentation will be the average of all the class scores. I will go over the evaluation form with you prior to the first presentation. Remember that your final research report and the presentation will constitute your grade for the lab activity, so do a good job.

Hints for making a good presentation

What works…

Using visuals on an overhead projector

Handouts — one for each member of the class

Posters with large print

Staying calm

Video clips, slides, photographs, computer use, PowerPoint

Good eye contact

Speaking slowly and clearly, projecting your voice as if you were speaking to the person furthest away from you

Knowing the material

Having an opening and closing statement

Preparing in advance

Being enthusiastic — after all, you did the research

Explaining scientific terms/data — maybe using analogies to help people understand better

Knowing the vocabulary that you use

What does not work…

Only having one handout and passing it around the class
Mumbling
Winging it
Reading directly from your notes
Not knowing your topic thoroughly
Not talking loud enough
Monotone voice
Having no visual materials to enhance your talk

Advice…

Do not say "um," "er," "uh"...
Plan in advance
Bring enough handouts for everyone in the class, including the teacher
Speak in complete sentences
Do not stress out — you are the expert
Do not rush — take your time
Use visual aids
Stick to the subject
Speak loud and clear
Be enthusiastic
Do not spend all the talk looking at your feet!

APPENDIX VI: Rubric for Presentation Evaluation

ORAL REPORT EVALUATION

Presenter's Name: ______________________________

Title of Report: ________________________________

Student shows:	Low				High
1. knowledge of subject	1	2	3	4	5
2. good voice projection	1	2	3	4	5
3. good eye contact	1	2	3	4	5
4. good use of visual aids	1	2	3	4	5
5. creativity and enthusiasm	1	2	3	4	5
6. ability to remain focused	1	2	3	4	5
7. good response to questioning	1	2	3	4	5
8. evidence of thorough research	1	2	3	4	5
9. ability to present the material clearly	1	2	3	4	5
10. ability to summarize all views on the topic	1	2	3	4	5

Evaluator's Name: ___________________________ **Total Score:** _________