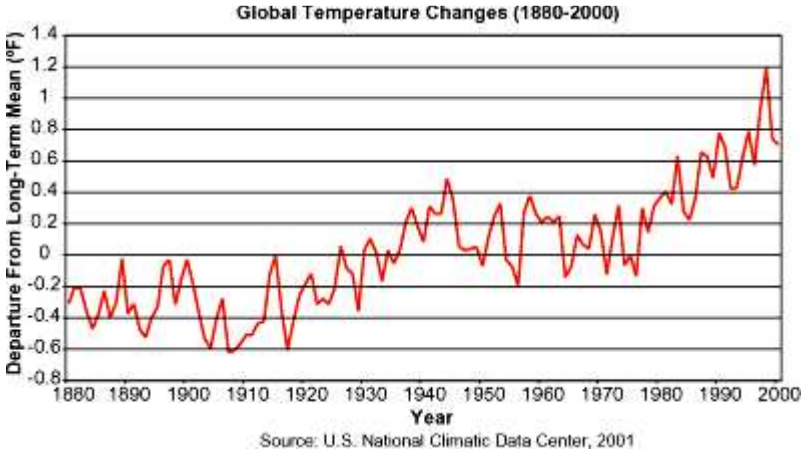
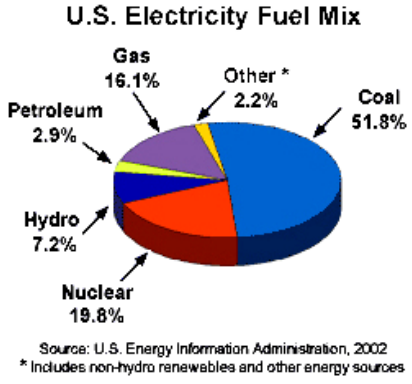
A Bright Idea for the Environment

Global warming in the last century is well documented. Over this time period, average surface temperatures on Earth have risen about 0.6°C (1.0°F), as shown in the line graph here. Many scientists believe this warming is due, at least in part, to human activity – the addition of greenhouse gases to Earth's atmosphere above levels that occur naturally. Greenhouse gas emissions by mankind include carbon dioxide (CO_2), methane (CH_4), fluorinated organic compounds such as CFCs, and a variety of other chemical substances. Human contribution to global warming is known as the *enhanced greenhouse effect*.

The historical record of atmospheric carbon dioxide concentrations is telling: During the same period in which global temperatures have been rising, the global CO_2 concentration has increased by one-third, from 280 parts per million (ppm) to about 380 ppm. The latest data give no sign that this trend is leveling off. The most likely culprits in rising CO_2 concentrations are the burning of fossil fuels and large-scale deforestation.





As the largest user of energy in the world, the United States depends heavily on fossil fuels to meet its energy needs, including the production of electricity. The pie chart shows that the U.S. generates more than 70 percent of its electricity by burning fossil fuels – oil, coal, and natural gas. About one-third of this electricity usage is for domestic (household) purposes.

How can Americans reduce the burning of fossil fuels that contribute to the enhanced greenhouse effect? One important way is by reducing electricity use in the home.

Fortunately, there are some relatively simple things we can do to save energy, like turning off lights when leaving a room or washing only full loads of laundry. Actions like these don't cost anything to implement, but they do require slight adjustments in our thinking and lifestyles. Other actions do have costs, but they save money in the long run by reducing electric bills – for example, replacing older appliances with new, energy-efficient models. (Look for devices that carry the ENERGY STAR label.)

One action that can significantly reduce electricity use is to replace standard incandescent light bulbs with energy-efficient compact fluorescent bulbs (CFBs). These bulbs come in a variety of shapes and sizes; many resemble incandescent bulbs, as seen in the examples at right.

The problem with incandescent bulbs is that less than 10 percent of the energy goes into creating light; the rest is wasted as heat. CFBs are three to four times more efficient in turning electricity into light, so there is far less energy wasted. A 23-watt CFB will be about equal in brightness to a 75-watt standard bulb. Compare the approximate costs and life expectancies of these bulbs:

Comparison of Incandescent and Fluorescent Compact Bulbs

Bulb Type	Typical Purchase Price*	Life Expectancy (hr)	Purchase Cost per 1000 Hours	Energy Cost per 1000 Hours**	Total Cost per 1000 Hours
75W Standard Incandescent	$0.75	750	$1.00	$7.50	$8.50
75W Longlife Incandescent	$1.50	1500	$1.00	$7.50	$8.50
23W Compact Fluorescent	$6.00 - 12.00	8,000 - 10,000	$0.75 -1.20	$2.30	$3.05 - $3.50
* 2004 dollars		** based on an assumed energy cost of $0.10/kWh			

As the last column shows, the total cost of a CFB can be less than half the cost of an incandescent bulb because of the large savings in energy. *Here is a clear example of an energy conservation measure that is not just good for the environment but also beneficial to your wallet!*

Home Lighting Audit

Students can get an idea in advance as to the energy cost savings that CFBs would provide in their own homes. The lighting audit presented here uses a simple format for calculating annual lighting costs and expected savings that would result from replacement of standard bulbs with CFBs. To begin, the approximate cost of electricity, measured in dollars per kilowatt-hour (kWh), is needed. This may be calculated from a household's monthly electric bill, as follows: Divide the total dollar amount for monthly energy usage by the total number of kilowatt-hours used.

$$\text{Average cost per kilowatt-hour (\$/kWh)} = \frac{\text{Dollar amount of monthly bill}}{\text{Monthly energy usage (kWh)}}$$

The annual energy cost of any light bulb can be estimated with the following formula:

$$\text{Annual energy cost (kWh)} = (W \div 1000) \times h \times 365 \times \text{\$/kWh}$$

where kWh = kilowatt-hours
W = bulb wattage
W ÷1000 = bulb wattage converted to kilowatts
h = estimated number of hours bulb is turned on daily
365 = number of days in one year
$/kWh = cost of electricity per kilowatt-hour

Home Lighting Audit

Use this table to simplify the calculation of energy costs and savings for home lighting. Complete the table for any number of rooms or for an entire house. Where multiple, identical bulbs are used for the same purpose in one room, use a single line. More than one sheet may be needed.

Enter the average cost per kilowatt-hour ($/kWh):

Location / Use / Incandescent Bulb Type	Number of Bulbs (n)	Bulb Wattage (W)	Est. Hours per Day (h)	Annual Energy Used (kWh) = n × W × h × 0.365	Annual Energy Cost ($) = kWh × ($/kWh)
Totals:				kWh	$

The potential energy savings from using CFBs is about 70 percent. Multiply each of the above totals by 0.70 to obtain estimated savings in annual energy used and annual energy cost:

Estimated Savings:	kWh	$

Assuming the source of electricity is fossil fuels, the reduction in carbon dioxide emissions from this energy savings is about 2 lb (0.9 kg) per kWh of energy saved, varying somewhat with the power plant and fossil fuel type. Multiply the last value at right by 0.9 to estimate the potential CO_2 reduction from this energy savings.

Estimated CO_2 reduction:	kg

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Teachers' Notes

Objectives: Students will learn that there is a relationship between global warming and the burning of fossil fuels. Students will conduct home lighting audits to achieve a better understanding of how their own practices may contribute to global warming, and discover how they may reduce personal energy use.

Grade Level: Middle/High

NSES: A3, A4, A5, A6, B6, B11, E4, E5, E6, E7, F10, F13, F14, F15, F16

NHSCF: 1a, 2c, 2e, 2f, 3c, 4b, 4c, 5c, 6a, 6b

Key Concepts

There is strong correlation between rising global temperatures and increasing levels of greenhouse gases in Earth's atmosphere, especially carbon dioxide. Most CO_2 in our atmosphere derives from natural processes, but the additional quantities released into the atmosphere by human activity since the beginning of the Industrial Revolution are the apparent reason for steady increases in CO_2 concentrations. A major cause of anthropogenic CO_2 emissions is the burning of fossil fuels for transportation, heating purposes, and electricity generation.

With respect to this last category, some 70 percent of electric production in the U.S. is dependent on fossil fuels. Once this fact is known, it is easy to make the connection between personal energy use and global warming. The opportunity for students to consider their own use of electricity is also an opportunity to consider the environmental consequences of electricity use. It is possible, for example, to equate a simply action like turning on a light switch with adding more carbon dioxide to the atmosphere.

The choice of a household lighting audit to reinforce the connection between electricity use and global warming has several advantages: 1) All students use electricity at home, sometimes wastefully. 2) The technical and mathematical aspects are quite manageable, especially when the data collection and computational procedures are preformatted. 3) The data that students collect has real meaning to them. 4) Students can quickly "put a number on" the costs and benefits of their own energy-using behaviors. 5) The potential energy savings that students identify are realistic and achievable, should they decide to act on their findings.

The final calculation in the lighting audit is to determine the potential reduction in carbon dioxide emissions. The computed estimate is based on the assumption that all energy savings would come in the form of reduced burning of fossil fuels. The actual fossil fuel reduction would depend on the particular fuel mix in the regional electric distribution system.

Relevant fact: The average personal CO_2 emissions in the U.S. are 5,500 kg per year. *That's 100 times the mass of a 55-kg student!* Total per capita CO_2 emissions in the U.S. (including contributions from all sectors) are about four times that amount.

For general information on energy and energy conservation, visit these websites:

http://www.eia.doe.gov/ *(includes kids' page)*
http://www.energystar.gov/index.cfm?c=about.ab_index
http://energy.cr.usgs.gov/energy/stats_ctry/Stat1.html - consumption
http://www.stonyfield.com/EarthActions/Home/a-healthier-home.cfm

For greenhouse gas emissions calculators, visit these websites:

http://yosemite.epa.gov/OAR/globalwarming.nsf/content/ResourceCenterToolsGHGCalculator.html
http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterToolsCalculatorsWheelCard.html *(downloadable wheel-card calculator)*
http://www.airhead.org/Calculator/
http://www.americanforests.org/resources/ccc/index.php