The School Energy Audit: A Bright Idea

How can you save the environment and save your school money at the same time? Just follow our simple and straightforward school energy audit, and you will be on the way to helping the environment, learning about climate change from a multiple disciplinary perspective, and improving your school. Through this process, you will discover exactly how your school uses energy on a daily basis. The audit will cost the school little or no money and, if acted upon, will likely save your school money on its energy bill for this year and many years to come. The function of an energy audit is to expose different ways to affect energy consumption and identify numerous options for reducing energy consumption.

The money your school saves will be available to fund important school projects, but just as important, energy savings help the Earth by reducing resource use and environmental pollution. By improving efficiency in places like our schools, we can get the same benefits while using less energy. For example, substituting energy efficient compact fluorescent light bulbs (CFL) for standard incandescent bulbs will save on average up to 6,000 megawatts of electricity each year. That is a savings equivalent to the annual energy output of ten large coal-fired power plants or about seven average nuclear plants. Similarly, if every household in the U.S. replaced just one incandescent light bulb with a CFL, it would prevent enough pollution to equal removing one million cars from the road, about 1,000 pounds of pollution saved per bulb.

This program will help you and you class conduct a school energy audit and present your findings in a report to others. To do this, you will need to:

▪ collect data about the energy use of your school through auditing and accounting
▪ analyze the data from auditing and tracking energy use through projects
▪ write a report on your findings and make recommendations about how to improve school energy use
▪ present your findings and recommendations to school officials and try to get some of your recommendations adopted

Beginning Exercise:

As a class, list some factors that influence how your school uses energy.
1.
2.
3.
4.

Accounting – Understanding Your Bills

Next, spend some time going over your school's bills to see how it is billed for the resources it uses.

Project

Obtain data on the cost and use of energy, water, and garbage services at your school.

Equipment and Information needed:

1. School Resource Use Table (below)
2. School utility bills from the most recent year showing usage and cost
3. Information to understand how usage is converted to cost

School Resource Use Table

Month	Electricity KWH	Cost $	Natural Gas Therms	Cost $	Fuel Oil Gallons	Cost $	Water Gal	$
JAN								
FEB.								
MAR								
APR								
MAY								
JUNE								

JULY								
AUG.								
SEPT.								
OCT.								
NOV.								
DEC								
Total								
Total Cost								

Lighting Audit

Going renewable through wind, solar, geothermal, etc… is a self-evident method for saving the planet while reducing your energy output. If you can do it yourself or find an energy supplier that provides one of the aforementioned resources, by all means pursue such an option. However, not every school has the access or capacity to go renewable right now, much less implement even a solar water heater. Therefore, the reformation of your school's lighting system is one method that any school can do to drastically and easily conserve energy. Lighting your school takes energy and money, but so does the maintenance of the lighting system. As the chart below shows, incandescent bulbs have to be replaced more often than fluorescent ones, leading to longer maintenance hours spent on lighting.

Performance Characteristics of Various Light Sources

Lamp Type	Efficacy (Lumens/Watt)	Average Life (Hours)
Standard Incandescent	5-20	750-1000
Tungsten-Halogen	15-25	2000-4000
Compact Fluorescent (5-26 watts)	20-55	10,000
Compact Fluorescent (27-40 watts)	50-80	15,000-20,000

Problem:

You are about to buy a light bulb for $5.50 that has a rated life of 850 hours. You then notice that you can buy a bulb that produces the same light for 18,000 hours, but costs $62.00. Energy use is the same for each bulb. Which bulb is the better bargain?

_____ The $5.50 bulb_____ The $62.00 bulb

*Hint: you will have to buy about 21 bulbs with a life of 850 hours to get 18,000 hours of service (21 X 850 = 17,850 hours). Those 21 bulbs will cost you approximately $115.50!

Project

Do a Lighting Inventory for your school and complete the Room Lighting Checklist below.

Equipment needed:

1. Tape Measure
2. Light meter
3. School Room Locator
4. Lighting Survey Form (below)

Procedure:

1. Determine lamp type for room
2. Take Light Level Readings (Foot-candles)
3. Record number of light bulbs and their wattage
4. Record how lights are controlled
5. Record number of tubes per fixture (Luminare)

Write a report analyzing how well your school performs relative to existing lighting standards in your area.

Room Lighting Checklist

Room Number	Room Use(*1*)	Incandescent Bulbs Watts(*2*)	Fluorescent Lamps Watts(*2*)	High Intensity Discharge and Wattage(*2*)	Foot Candles(*3*)	Comments(*4*)

1. Room use: List primary activity such as science, office, art, etc.
2. Bulb Count/ Watts: Identify the type and number of bulbs and their wattage. If applicable, include ballast type and wattage.
3. Foot Candles: The reading obtained from the light meter at a set location.
4. Comments: Does the room have windows and/or skylights? Are the reflectors dirty? Is the ceiling reflective?

Water Audit

There are many ways you can help your school save money on water usage, such as checking for leaks in the system, reducing water usage (especially hot water), and improving the efficiency of water delivery.

Problem: Measuring Flowrates

Use a one gallon container in the school gym showers or a sink to determine the flow rate in gallons per minute. To measure the flow rate, turn on both the hot and cold water and adjust the temperature of the water and the flow to the temperature at which you would normally shower or wash your hands. Note the time on a watch (with a second hand) and fill the one gallon bucket, recording how much time it takes to fill in seconds.

1 gallon shower/sink water = _____ seconds. Divide this number by one and multiply the result by 60 to get gallons per minute = _____GPM.

Now turn off the cold water and find out how long it takes to fill the one gallon container with hot water.

1 gallon hot water = _____ seconds. Again divide this number by one and multiply the result by 60 to get gallons hot water per minute = _____GPM.

*Low-flow showerheads are available that provide hot showers and use only 2.5 GPM or less. If your flow rate is in excess of 2.5 GPM, energy can be saved by changing the shower heads. The same is true for automatic sink sensors, which appropriate and conserve sink water and reduce cost over a greater period of time.

Project

Find the following information about your school:

1. Amount of hot water (gallons) used per month (record on table below)
2. Amount of electricity (KWH) or natural gas (Therms) used per month to heat water
3. GPM (flow rate of school showers/sinks in gallons per minute)
4. Volume of water used in cubic feet per minute
5. Energy cost per cubic foot* and per gallon
6. Number of calories* of energy needed to heat water per gallon and per liter (Note: 2.78 Liters = 1 gallon)

*One cubic foot equals 7.69 gal
*One calorie equals the amount of energy necessary to heat 1 gram of water 1 degree Centigrade. 1 gram of water is equal to a milliliter.

Calculate the amount of energy used to heat water at your school:

Equipment needed:

1. Thermometer
2. One gallon container
3. One liter flask

Information you will need:

Total amount of hot water used per month (cubic feet)
Type of energy used to heat water (fuel, natural gas, electricity)

1. Measure the temperature of both cold and hot tap water using a thermometer that measures in Celsius, then find the difference between the two.

2. How many calories does it take to heat a liter of water at your school?

3. How many calories does it take to heat a gallon of water?

4. How many calories does it take to heat a cubic foot of water? (There are 7.69 gallons per cubic foot)

5. How many calories does it take to heat the water your school uses each month? (About one third of the total water used is heated).

Convert Total Calories (#4) to:
6. Kilowatt Hours _____

7. Calculate the cost of meeting the hot water needs at your school per month using a gas water heater and an electric water heater.

8. Record your conclusions regarding water heater efficiency, system efficiency, and rates.

True or False:
If incoming water is preheated by running through solar panels, it will take less energy to heat the water and will save money. ___T ___F Why or why not?
(Answer is True, since over a given period of time, heating is on-site (cheaper) and the only related costs are for maintenance, with sell back options being a perk.)

Write a report presenting your findings relating to water use in the school.

School Hot Water Use

Month	Cubic Feet (CF)	Gallons (Gal)	Liters (L)	Energy Dollars ($)
JAN				
FEB				
MAR				
APR				
MAY				
JUNE				
JULY				
AUGUST				
SEPTEMBER				
OCTOBER				
NOVEMBER				
DECEMBER				
Totals				

Food Services Audit

In the Kitchen
In some areas you will pay more for the electricity used by some refrigerator models during their lifetimes than you originally paid for the refrigerator. Alternatively, more efficient models (energy star appliances) are available and could be more cost effective than the equipment at your school.

Pilot lights use as much as 30% of all the gas a range uses, so turn them off over breaks or long hours of non-operation.

Problem:
In an experiment, cooking the same recipes in the same kitchen with the same utensils, some cooks can use half as much energy as others. How?

Answer:

a. Using pots about the same diameter as the burner
b. Using lids on their pots
c. Using a pressure cooker instead of a regular pot
d. Turning the burner off a few minutes before the dish is done
e. Deciding what is needed before opening the refrigerator door
f. Taking from the refrigerator everything needed for a meal at once
g. Running only full loads in the dishwasher

Project

Inspect the food service area of your school and evaluate the conditions.

Equipment Needed:

1. Thermometer

Complete the following cooking and dishwashing checklists.

Cooking

Yes	No	Commercial Food Service Energy Conservation Checklist
		Second fry unit, broiler, oven, etc. used only for peak business hours.
		Oven preheats at desired temperature; not at a higher temperature.
		Smaller energy efficient ovens used whenever possible.
		Ovens loads and unloads quickly to avoid unnecessary heat loss. Every second an oven is open it loses about one percent of its heat.

		Cooking and heating units not in use are turned off.
		Meat cooked slowly at low temperatures. Cooking on roast for five hours at 250º F saves 25-50 percent of the energy used in cooking for three hours at 350o F.
		Baking and roasting scheduled so that oven capacity can be fully utilized.
		Ovens are not opened during operation.
		Food cooked on small part of grill heating only portion being cooked on.
		Fryers cleaned and oil filtered at least once a day.
		Food warmers and hot plates turned on only as needed.

Dishwasher - Water Heating

Yes	No	Dishwasher and Water Heating
		Water at 75o F on closing, at 140o F two hours before opening.
		Drain water heater every six months.
		Use hot water only when necessary.
		Dishwashers run only when there is a full load.
		Hot water heater coils free from lime accumulations.
		Leaking faucets?
		Water pressure regulators on hot water lines to reduce wasted hot water.
		Hot water lines insulated?
		General-use hot water temperature at 140º F. Taps at 110o F.
		Cleaning done during daylight hours?
		Mop from bucket to conserve hot water?

Additional note to the kitchen audit: creating a nature center, greenhouse, or school garden on-site can significantly reduce energy and food costs for your school. It also provides a hands-on learning experience for many disciplines, and provides a healthier alternative to junk food, soda, and other unhealthy options common to schools. In fact, a separate project could consist in finding local sources for your food service, used as an addendum to this audit to manifest greater monetary savings and benefit to the environment.

Recycling

Another important way to save energy at your school is through recycling. This can be done all over the school. For example, you can save by recycling paper milk cartons from the lunch room or printer cartridges in the copy room. By recycling paper, milk cartons and other materials, schools are able to reduce the amount of waste they produce. This can garner significant savings as well as benefit the environment. Become familiar with

your school's solid waste contract and resources in your community relating to solid waste. In many communities there are individuals and organizations that will help you set up a program that is appropriate for your school and geographic area.

Using materials over again can save energy, so get creative. Half of a two liter bottle can become a pot for growing plants, or glass bottles can become a piece of art. To illustrate, it takes about 20 times more energy to get aluminum from ore (bauxite) than from used cans, so it makes a lot of sense to reduce, reuse, and recycle.

Additionally, buying items and selecting options that will last a long time, can be repaired if they break, are made from recycled materials, can be recycled, and have minimal packaging are all excellent ways of saving energy.

The Project Report

Once you have completed the work in this program you are ready to assemble your data and make formal energy recommendations. Make an appointment with the appropriate individuals responsible for operation and maintenance of the building to present your energy audit findings. Try to identify the major sources of energy use and evaluate how much it will cost to implement your recommendations. Further, estimate payback by comparing the cost of your recommendation divided by the energy saved each year. For example, if it costs $18,000 to do a lighting retrofit that saves $6,000/year, the payback is $18,000/$6000yr = 3 yr. Thus, after only 3 years, you can start reinvesting saved money back into the improvement of your school.

Energy Savings Recommendation	Cost of recommendation	Projected energy savings/yr	Payback(years)

SUPPLEMENTAL MATERIALS: ENERGY AND THE ENVIRONMENT

Environmental Costs of Energy

People who buy gasoline for their cars do not pay for many of the costs associated with the production of cars or fuel. The Environmental Protection Agency (EPA) estimates that (on a national average) for every kilowatt-hour of electricity produced; 1.5 pounds of carbon dioxide (CO_2), 5.8 grams of sulfur dioxide (SO_2), and 2.5 grams of nitrogen oxides (NO_2 and $NO3$) are produced. When we view these values with respect to national

energy production, the amounts are enormous. If energy-efficient lighting were used everywhere it was profitable, the nation's demand for electricity would be cut by more than 10 percent. This would result in the following reductions:

- 202,000,000 metric tons of the greenhouse gas carbon dioxide (4 percent of the national total or the equivalent of the exhaust emitted from 44 million cars).
- 1,300,000 metric tons of sulfur dioxide (7 percent of the national total).
- 600,000 metric tons (4 percent of the national total).

Exercise: Incandescent vs. Fluorescent Lamps

A standard 60 Watt incandescent bulb costs $0.43 and a 9 Watt compact fluorescent bulb with adapter costs $9.95. Both produce the same amount of light. Which bulb is cheaper? In terms of the price of the product, the incandescent bulb is about twenty times more expensive. Complete the table that follows using these values:

	Incandescent bulb	Fluorescent bulb
Price	$0.43	$9.95
Lifespan (hrs)	1000	10,000
Energy used per hour (W)	60	9

Externalities per kilowatt-hour:

Carbon dioxide CO_2 .....1.5 lbs
Sulfur dioxide SO_2..... 5.8 grams
Nitrogen oxides NO_x .. 2.5 grams

When you buy a light bulb you are really buying both the light and the energy necessary to operate that light. Complete the table and answer the questions that follow. To make calculations simple, evaluate the cost of 10,000 hours of light using both the incandescent and the compact fluorescent bulb given in the above example.

Bulb type	Cost[1]	Cost 10,000 hr	Watts	KW	Energy cost ($.06/KW)	CO_2 Grams	SO2 Grams	NOX Grams
Incand.	$0.43							
Comp. Fluor..	$9.95							

Incandescent bulb lasts 1,000 hours; Compact Fluorescent bulb lasts10,000 hours.

Financial costs:

1. What is the cost of 10,000 hours of light using incandescents?

Hint: ($4.30 bulbs + $36.00 energy)

2. What is the cost of 10,000 hours of light using compact fluorescents?

3. The Incandescent bulb uses_____% more electrical energy than the compact fluorescent bulb.

Environmental Costs:

4. The Incandescent light produces _____% more carbon dioxide than the compact fluorescent lamp.

5. The Incandescent light produces_____% more nitrogen oxides than the compact fluorescent lamp.

6. List some of the problems associated with increasing amounts of carbon dioxide CO_2 in the environment:
A.
B.
C.

7. List three problems associated with increasing amounts of *sulfur dioxide* SO_2 and *nitrogen oxides* NO_x in the environment:
A.
B.
C.

The Cost of Light

Many of us think about energy as an unavoidable, fixed cost of living. Energy costs are neither unavoidable nor are they fixed. You already know that to buy light there is the cost of the light bulb and the energy costs of running the light. According to the EPA, fluorescent lamps, though very efficient when compared to incandescent lamps, have high energy costs. In fact, 90% of the cost of fluorescent light is energy, 6% is in the materials of the lamp, 3% in the labor to produce the lamp, and 1% in recycling costs. Fortunately, new technology has dramatically improved the efficiency of fluorescent lights from about 45% to over 90% in some cases.

Energy Costs in the Future

Problem:

Based on what you have read, seen on television, or have heard from others, what do you think energy prices, in dollars, are likely to do in the future?

Team Exercise:

Identify the reasons why energy costs may go up and then discuss reasons why or why not.

	Reasons for Energy Costs Increasing	Reasons for Energy Costs Decreasing
1		
2		
3		
4		
5		
6		

Efficiency

Efficiency is defined as the proportion of usable energy that remains after each step of a transfer process. If each part of a system worked as efficiently as possible it would use the least amount of energy required to get the job. This ideal is the ultimate goal of any energy management program and of this school project. There three methods of reducing energy use are: (1) reduce system use, (2) use the system more wisely, and (3) make the system more efficient.

Example: Three methods can be used to reduce the energy consumption of a typical automobile. The first method is to drive the car less. The second method is to alter driving habits such as driving the car at 50 MPH (the most efficient speed), avoiding panic stops and accelerating slowly. The third method is to ensure that all systems in the car that affect energy consumption are operating as efficiently as possible. Radial tires generally give better gas mileage than non-radials because of reduced rolling resistance. An engine with a plugged fuel injector or misfiring spark plug will use considerably more gasoline than one that is operating properly. Tires inflated to the correct pressure give better gas mileage than under-inflated ones.

Question:

Sally owns a 1981 Toyota Corolla and wants to get better gas mileage. She drives to and from school but not over long distances. Should she: (Check one below)

_____ *Spend $29.95 for a wax job or*
_____ *Inflate her tires to the recommended level?*

Although a building is obviously different than a car, the basic principles remain the same. Maximum energy savings can be achieved by considering all of the options and the way these different options impact each other, the potential benefit versus the cost, and numerous other factors.

Energy: A historical, global perspective

Fossil evidence suggests that the most recent form of our species, *Homo sapiens sapiens*, has lived on Earth for only about 40,000 years, a brief instant in the planet's estimated 4.6 billion year existence. During most of this time, we lived as hunter-gatherers. More recently, the Agricultural Revolution (10,000 to 12,000 years ago) and the Industrial Revolution (165 years ago) increased the amount of energy available to humans. The Agricultural Revolution freed humans from constantly searching for food (energy) and allowed communities and civilizations to form. The Industrial Revolution of the 1840s enabled the use of energy from fossil fuels to power new technologies applied to food production and manufacturing. Since the Industrial Revolution, there has been an enormous increase in the average direct and indirect energy use per person in all developed countries.

Energy Used Per Person at Various Stages of Human Culture Development

Cultural Development	Kilocalories per Person/Day
Primitive	2,000
Hunter Gatherer	5,000
Early Agricultural	12,000
Advanced Agricultural	20,000
Early Industrial	60,000
Modern Industrial (other developed nations)	125,000
Modern Industrial (United States)	230,000

Notice in the table above that the average energy consumption of each of us in the United States is 230,000 Kilocalories per day while the rest of the developed world uses only 125,000 Kilocalories per day. We use almost twice as much energy per person than people who live in countries like Germany and England, for example. With only 4.7% of the world's population, we use 25% of the world's commercial energy. Therefore, a vast potential exists for reducing our energy consumption and becoming more energy efficient. The only bad idea here is not taking action, and that is something you, your school, and the planet cannot afford.

Conclusion: Reducing one's energy consumption, whether at school, the office, or home, is something that everyone can participate in a number of ways. If it means changing out light bulbs or overhauling your cafeteria's food service for healthier, local options, we can all work together in making our lives more energy efficient, and thereby, invest in a better world for all. For additional information on how you can take more action for your school or the Earth, visit our website at www.earthday.net.

Additional Action Items:

- Turnoff lights in empty hallways when not in use
- Seal outer doors

- Upgrade rooftops and other insulation materials
- Replace, old leaky windows with low R-value ones
- Apply for grants to finance other conservation efforts
- Install new, automatic setting thermostats
- Place caulking and weather-stripping around doors and windows
- Use the PA system to announce energy tips
- Film or write “How To” manuals for basic actions
- Implement a school-wide energy poster campaign
- Cover Sun-facing windows with UV film or shades
- Put LED lights in Exit signs
- Install light sensors in all applicable rooms
- Place light reflectors in hallways
- Perform educational energy tours to show other schools your success
- Plant trees to provide shade or act as wind barriers
- Add insulation where there was none before
- Use more natural light in classrooms
- Change outdoor lights to be triggered by motion sensors
- Seek funding programs that offer employment positions for students to do energy audits
- Track the energy use and cost per hour of electrical equipment used in the school and post this information on the equipment
- Buy solar water heaters
- Install infrared sensors in closets and bathrooms
- Keep classroom doors closed in winter to keep in heat
- Place curtains over windows to keep heat in or sun out
- Educate custodial staff about energy conservation issues
- Initiate ticket program for people who forgot to turn off lights
- Construct inner doors by main entrances
- Keep an up-to-date inventory of electrical equipment, lighting, and so on in the school