School Energy Survey
Student Guide

2016-2017

NEED
National Energy Education Development Project

SECONDARY

Energy Efficiency and Conservation Informational Text

Introduction

A school building is an energy system made of many interrelated components. Some of the components are obvious—walls, roofs, lights, air vents, doors, and windows. The occupants—students, teachers, and other building users—are also an important part of the system.

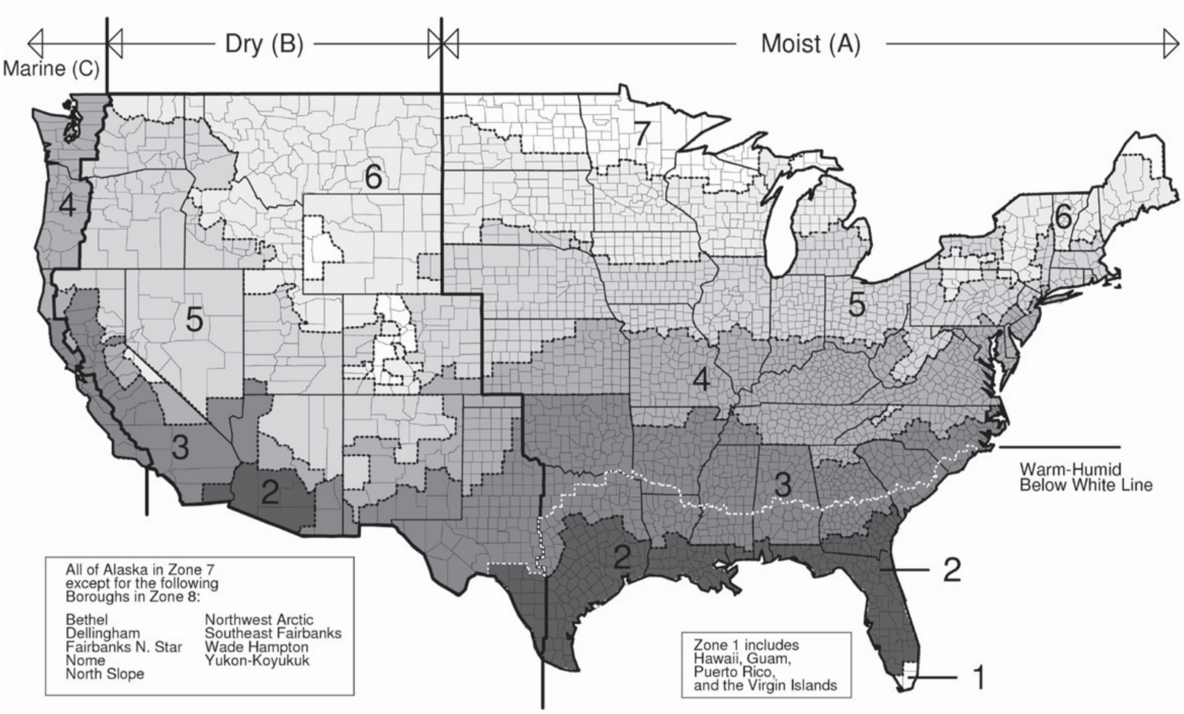
The **energy** use of the system affects everything from the school budget to the global environment. It is important to understand how all of the system components can work together to create an environment that is conducive to teaching and learning. A school building's energy system includes these components:

- **Building Envelope:** This component includes everything that creates barriers between indoors and outdoors—walls, floors, roofs, windows, and doors.
- **Heating, Ventilation, and Air Conditioning (HVAC) Systems:** This component includes the equipment that provides heating, cooling, hot water, and fresh air to the building. It also includes the devices that control the equipment, such as thermostats.
- **Lighting:** This component includes several types of fixtures that provide lighting for all of the areas and activities in the school.
- **Electrical Devices:** This component includes everything that is plugged into electrical outlets, such as refrigerators, copiers, and computers, as well as kitchen appliances that are wired directly into the school's electrical system, such as ovens and refrigeration units.
- **Occupants:** Buildings don't use energy, people do. The actions of the building occupants dictate how much energy is used by the other system components. The other four components all include points of human interface, and in the sections where they are described, suggestions are provided for how people can use energy more efficiently.

The amount of energy each of these components consumes varies according to where a school is located. The U.S. Environmental Protection Agency has determined Climate Zones for all parts of the country.

Schools in the northern part of the country and Alaska (Zones 6–8) use more energy for heating than any other use, while schools in southern areas of the country and Hawaii (Zones 1–2) use more energy for cooling and lighting. Look at the map below and brainstorm what are likely to be the large and small energy tasks in your school.

Climate Zone Map



Data: U.S. Environmental Protection Agency

The School Building is a System

When managing the systems of a school to minimize energy consumption, it is important to maintain the health and comfort of the occupants. After all, the primary reason energy is used in a school is to provide a comfortable and supportive learning environment.

Human beings have specific physical requirements for temperature, relative humidity, and general air quality. They also have requirements for the quality and quantity of lighting. If light levels are too low, or of poor quality, they can cause eyestrain, headaches, and safety issues.

Turning off lights and lowering the heat in winter can save energy, but doing so without consideration of the impact on the building's occupants can cause unsafe or unhealthy conditions in the building. When the building is treated as a system, energy is saved while maintaining or improving the indoor environment.

According to the U.S. Census Bureau, just under 20 percent of the American population—nearly 60 million students—spend their days in our elementary, middle, and secondary schools. In the late 1990s, studies showed that one in five schools reported unsatisfactory indoor air quality. One in four American schools reported an unsatisfactory ventilation system, which impacts indoor air quality.

Students are at increased risk for getting sick during the hours they spend in unacceptable school facilities, because children are more susceptible than adults to environmental pollutants and poor air quality.

When the building is treated as a system, energy can be saved while maintaining or improving the indoor environment, because those managing the system are aware of how decisions regarding energy use— particularly with HVAC systems— impact the indoor environment.

School Energy Survey

You can learn about how your building uses energy by conducting an energy survey. These surveys are also called **energy audits**. The results of the survey will help you understand ways in which the school could use energy more efficiently. The last section of the guide also provides information on how to implement an energy awareness program in your school.

The information you will be gathering during the energy survey is similar to the work done by professionals in the energy management industry. Energy analysts perform energy studies on schools, businesses, homes, factories, and other buildings to determine cost-effective ways to save energy. The activities in this *School Energy Survey* are similar to the tasks performed by engineers and other technicians in this growing field.

How Your School Uses Energy

This section describes the various components of the building that should function together to provide a productive and healthy indoor environment. It also describes how energy is wasted and suggests ways to use energy more efficiently.

Building Envelope

All parts of the building that create barriers between the inside and outside are components of the **building envelope**. These parts include walls, floors, ceilings, windows, doors, and skylights. These components work together to reduce heat transfer. Any warm air that flows into the building during cooling season and out of the building during heating season wastes energy. The objective of the building envelope is to allow as little heat transfer as possible.

One way to reduce heat transfer is with **insulation**. Most school roofs are insulated; walls may also be insulated. Insulation is rated with an **R-value** that indicates the resistance of the material to heat transfer. The higher the R-value, the more effective the material is at slowing heat transfer. Insulation wraps the building in a blanket, slowing the transfer of heat through walls and roofs.

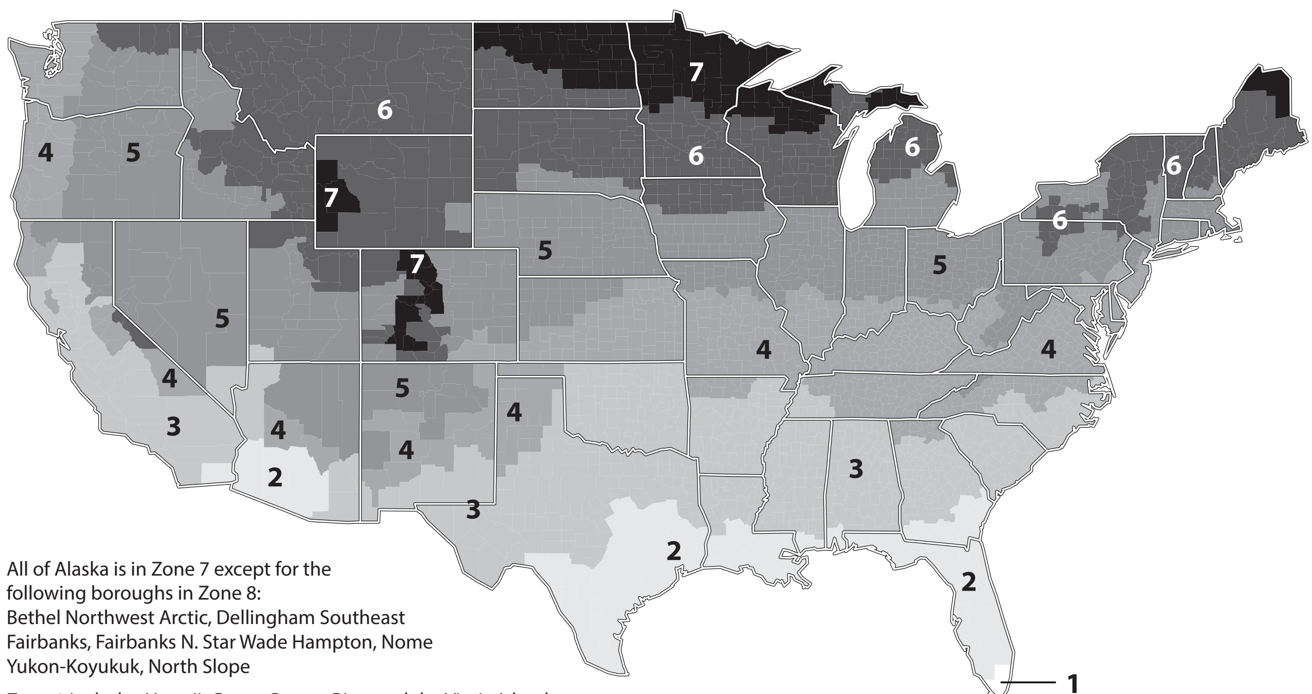
This type of heat transfer is called **conduction**, the flow of thermal energy through a substance from a higher to a lower–temperature area.

Air, carrying heat with it, can still leak in or out through small cracks. Often the many small cracks in a building add up to a hole the size of a wide open door. Some of these cracks are obvious— around doors and windows, for instance. But others are hidden behind walls and above ceilings. Sealing these cracks is a very effective way to stop another type of heat transfer—**convection**, the transfer of thermal energy through a gas or liquid by the circulation of currents from one area to another.

Doors should seal tightly and have sweeps at the bottom to prevent air leaks. It is common to be able to see daylight through cracks around school doors. Most schools have more windows than doors. The best windows shut tightly and are constructed of two or sometimes three panes of glass. Windows should be checked often to make sure they seal tightly and any cracks around the windows should be caulked.

When air transfer is minimized, the need for fresh air for the occupants must be considered. To provide fresh air and remove stale air, school buildings have mechanical ventilation systems.

Recommended R-Value of Insulation by Climate Zone



All of Alaska is in Zone 7 except for the following boroughs in Zone 8:
Bethel Northwest Arctic, Dellingham Southeast Fairbanks, Fairbanks N. Star Wade Hampton, Nome Yukon-Koyukuk, North Slope

Zone 1 includes Hawaii, Guam, Puerto Rico, and the Virgin Islands.

ZONE	ATTIC	CATHEDRAL CEILING	WALL INSULATION: CAVITY	WALL INSULATION: INSULATION SHEATHING	FLOOR
1	R30 to R49	R22 to R38	R13 to R15	None	R13
2	R30 to R60	R22 to R38	R13 to R15	None	R13, R19 to R25
3	R30 to R60	R22 to R38	R13 to R15	None, R2.5 to R5	R25
4	R38 to R60	R30 to R38	R13 to R15	R2.5 to R6	R25 to R30
5	R38 to R60	R30 to R60	R13 to R21	R2.5 to R6	R25 to R30
6	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25 to R30
7	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25 to R30
8	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25 to R30

Data: U.S. Department of Energy

In buildings with effective ventilation systems, even the windows can be sealed. With a good ventilation system, there should be no concerns about sealing all the air leaks in the building.

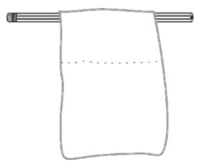
Landscaping

Although the weather can't be controlled, trees can be planted around buildings to block the wind and provide shade. This is an excellent way to make the building envelope more energy efficient.

Deciduous trees planted on the south side of a building block the sun in warmer months and allow sun to shine on the building in winter, when the leaves are gone. Conifers planted on the north side of the building can block the north wind. Properly placed trees and bushes can reduce the energy required to heat and cool a building.

Building Envelope: Savings Opportunities

One of the easiest energy-saving measures to reduce heat transfer is to caulk, seal, and weather-strip all cracks and openings to the outside, resulting in a 10 percent or more savings in yearly energy costs. Even more savings are possible if a company that specializes in **weatherization** or finding and sealing hidden leaks is employed.



One way to locate areas of air leakage is by using a draftmeter made from toilet tissue or paper and a pencil and tape. Tape a strip of the paper to the pencil and hold it near a window or door. The paper will move if there is leaking air.

Another way to determine if doors are leaky is to notice if you can see any light around the edges of the doors when they are closed. If gaps are letting light through, they are letting a lot of air through, too. Finally, sometimes doors and windows are left open when HVAC systems are in use. These conditions should be noted and corrected.

Is the building well insulated? You may not be able to tell, but by interviewing building operators you may be able to find out about the level of insulation in your building.

Outside the building, look to see if shading from evergreen trees is provided on the north side and shading is provided by deciduous trees on the south side.

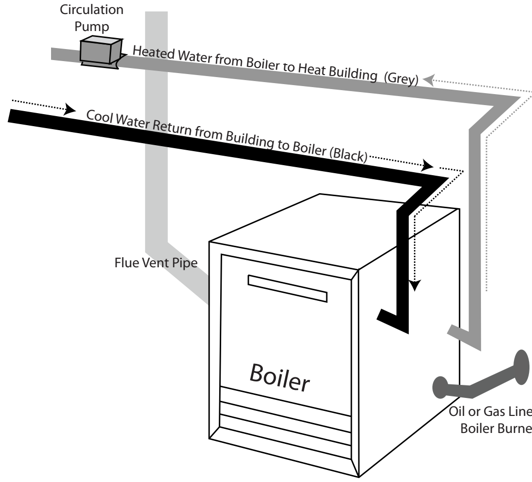
Heating, Ventilation, and Air Conditioning

In most parts of the country, **heating, ventilation, and air conditioning (HVAC) systems** use more energy than any other systems in a school. Natural gas or heating oil, and sometimes electricity, are used to heat most buildings; electricity is used to run cooling systems.

Ventilation systems are necessary to provide fresh air and remove stale air and indoor air pollutants. Between half to three-quarters of the average school district's energy bill is used to keep schools at comfortable temperatures, provide hot water, and provide fresh air for the buildings. The energy sources that power these heating and cooling systems emit millions of tons of carbon dioxide into the atmosphere each year.

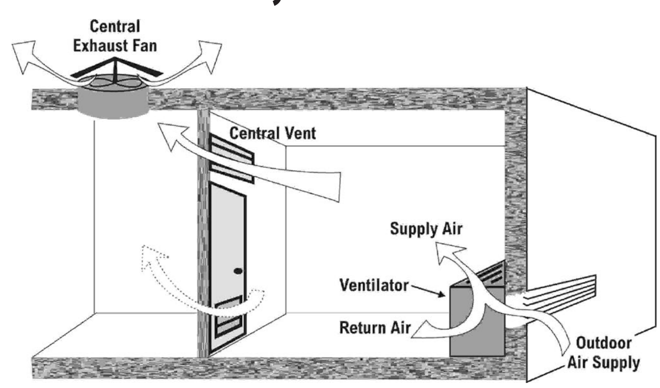
Most school buildings are heated by **boiler** systems. Boilers burn oil or natural gas to heat water to high temperatures (or even steam), which is then circulated throughout the building through a system of pipes. Once the water in the pipes has given up its heat to the air in the building, it is piped back to the boiler to be reheated.

Boiler System



Many classrooms are provided with heat, and some with cooling, by unit ventilators. A unit ventilator is a metal cabinet, usually located underneath a window. Inside the unit are pipes with hot and sometimes cold water. A fan inside blows across the pipes and provides heated or cooled air to the classroom through a **vent** on the top. A vent at floor level pulls air into the unit from the room. Finally, a vent leads outside to bring fresh air into the classroom. For a unit ventilator to work efficiently and effectively, the vents at the top and bottom must be kept clear of books, students, and other items.

Unit Ventilation System



Thermostats often control heating and cooling systems in the building. **Programmable thermostats** can be set for the desired temperature in the rooms. A thermostat is basically an "on-off" switch. In the heating season, when the temperature in a room falls below the setting, heat is delivered to the room. During cooling season, cool air is delivered in the same way.

Many school districts control how high or low the temperature can be set in different rooms. The most advanced systems use central computers to control heating, cooling, and ventilation. Temperature sensors in the rooms send information back to the computers, which adjust the temperature in the rooms to pre-programmed levels. They automatically control the temperature of buildings for time of day and can save energy and money.

During heating seasons, for example, they can lower the temperature at night and on weekends when no one is in the buildings. If requested, the building operator can adjust the program to provide heat and cooling outside of regular building hours for sporting events, meetings, or concerts.

For the HVAC equipment to operate at optimum **efficiency**, it is vital to keep the equipment well maintained. Periodic maintenance of equipment will ensure that boilers, chillers, ventilation systems, and controls are all functioning as they should. The school should have procedures in place that provide for regular maintenance of equipment. Even if school buildings have energy efficient systems, a lot of energy can be wasted if the energy is not managed wisely. That is where students and teachers learning about energy can help.

Air Quality, Moisture, and Relative Humidity

Moisture plays a major role in the indoor air quality of a building. **Humidity** is a measure of the total amount of water vapor in the air. **Relative humidity** is a measure of the amount of water vapor in the air relative to the amount of water vapor the air can hold, which is dependent on the air temperature.

Air acts like a sponge and absorbs water through the process of evaporation. Warm air is less dense and the molecules are further apart, allowing more moisture between them. Cooler air causes the air molecules to draw closer together, limiting the amount of water the air can hold. High relative humidity can be caused by people and their activities, such as showers, cooking, or drying clothes. Water can also come from plumbing leaks, wet boots, or splashing around sinks. Moisture can travel with outdoor air that leaks through the building envelope or with indoor air traveling from one part of the building to another.

It is important to control moisture and relative humidity in occupied spaces. Relative humidity levels that are too high can contribute to the growth and spread of unhealthy biological pollutants. This in turn can lead to a variety of health effects, ranging from more common allergic reactions, to asthma attacks and other health problems. This can be controlled using a **dehumidifier**.

In addition to health problems, high relative humidity or water that enters building cavities and is not allowed to dry quickly can lead to problems such as mold, rot, structural damage, and paint failure. Humidity levels that are too low, however, can contribute to irritated mucous membranes, dry eyes, and sinus discomfort. Maintaining the relative humidity between 40 and 60 percent ensures that the occupants are both comfortable and healthy. High humidity is uncomfortable for many people. If air is too dry a **humidifier** can be used to bring levels up to the desired amount for comfort.

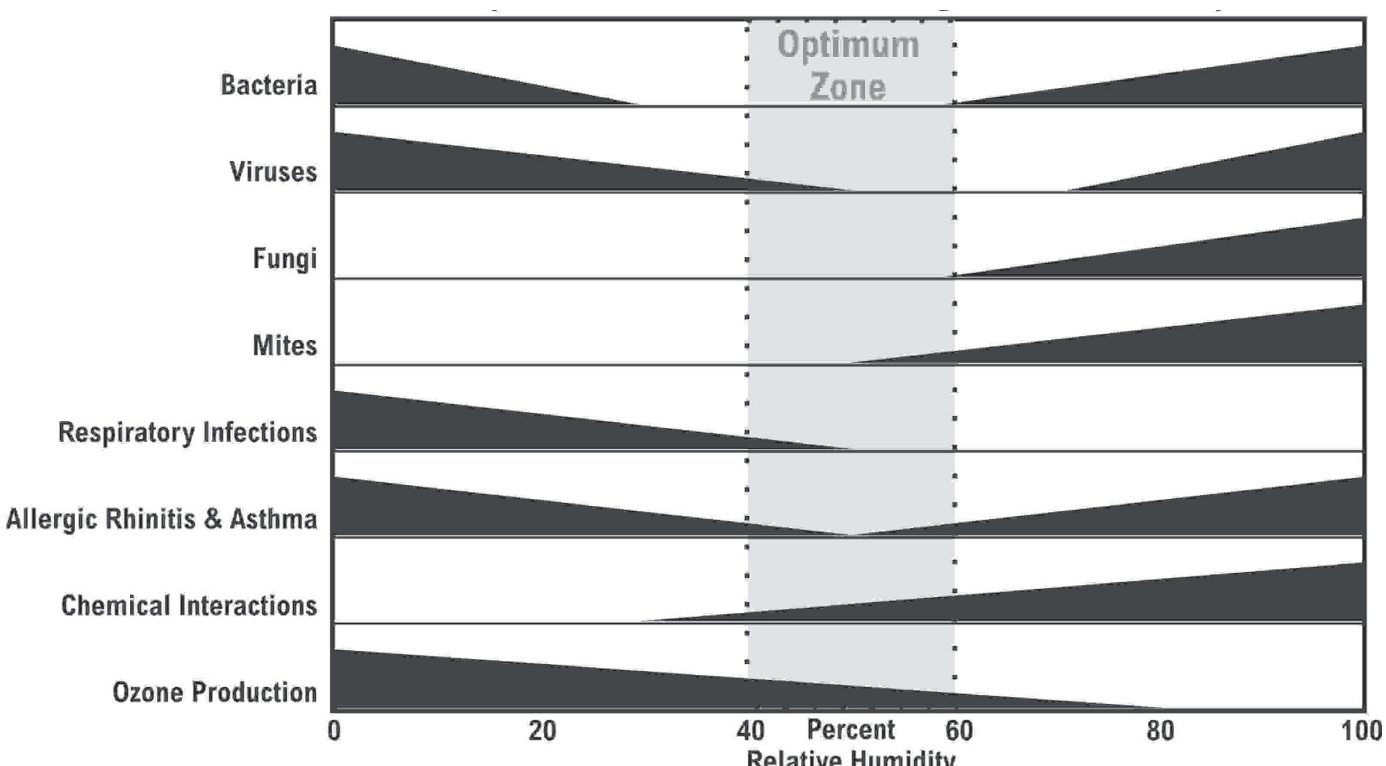
Humidity/Temperature Pen

You will measure relative humidity levels as part of your energy survey using a digital humidity/temperature pen. This pen measures indoor temperature and relative humidity and displays the readings on its face. It has a battery for power. It can display the temperature in Fahrenheit or Celsius at the touch of a button. When a tool measures humidity it is often called a **hygrometer**. The hygrometer displays relative humidity in terms of percentage. If the hygrometer reads 35%, it means that the air contains 35 percent of the water vapor it can hold at the given air temperature.

When the air contains a lot of water vapor, the weather is described

Health Effects of Relative Humidity Levels

(width of bar indicates magnitude of effect)



Data: U.S. Environmental Protection Agency as humid. If the air cannot carry any more water vapor, the humidity is 100 percent. At this point, the water vapor condenses into liquid water.

HVAC: Savings Opportunities

The best heating system in the world can't do a good job if outside doors or windows are left open, or if the temperature is not controlled. The same is true for cooling systems. In classrooms and offices, it is recommended that the temperature be set at 68°F (20°C) during the heating season and 78°F (25°C) during the cooling season during the day. Windows and doors should be closed when the heating and cooling systems are operating. If thermostats are in place, check the settings.

If the temperature of rooms can be individually controlled, districts should have a policy on acceptable temperature settings. Temperature ranges can vary depending on the functions of the rooms. Gymnasiums, for example, don't need to be heated as much as classrooms. Auditoriums, hallways, store rooms, and other infrequently used rooms don't need to be heated and cooled as much either.

Rooms and areas with windows in direct sunlight can be equipped with blinds to help control temperature—closed in cooling months and opened in heating months when sunlight is on them. When inspecting rooms during your survey, check to see if blinds are being used to increase energy efficiency. With all heating and air-conditioning systems, energy consumption can be minimized by making sure there is adequate insulation, maintaining the equipment, and practicing energy-saving behaviors.

Water Heating

Water heating is the second largest energy expense in residential buildings; it is usually a much smaller percentage of school energy use, but it is significant. Schools often heat water with the same boiler that is used to heat the school building. The water is stored in a separate tank that has its own burner, controlled by a thermostat to keep the water at the desired temperature.

Sometimes schools have large stand-alone water heaters, like those used in residences. These are usually fueled by natural gas or electricity. Heated water is used for showers, hand washing, dishwashing, and cleaning.

The five main ways to lower water heating bills are:

- use less hot water;
- make sure there are no water leaks or drips;
- turn down the thermostat on the water heater;
- insulate water heaters and water pipes; and
- buy energy efficient water heaters.

Other ways to conserve hot water include taking shorter showers, fixing leaks in faucets and pipes, and using the lowest allowable water temperature.

The easiest way to cut the cost of heating water is to reduce the amount of hot water consumed. This can be done with little cost and minor changes in lifestyle. Water-saving faucet **aerators** (which diffuse the flow of water) can be installed in restrooms and classrooms. They limit the flow of water while providing adequate flow for washing. Many schools also utilize spring-loaded faucets that limit the amount of time the faucet runs. During the survey, check to see if these are installed and if there are any faucet leaks.

Most water heater thermostats are set much higher than necessary. Lowering the temperature setting on a water heater saves energy. Lowering the temperature 10 degrees can result in energy savings of $12 to $30 per year. Installing energy efficient water heaters in school buildings can save hundreds of dollars a year. To conduct the survey, you will use a digital waterproof thermometer to measure water temperature.

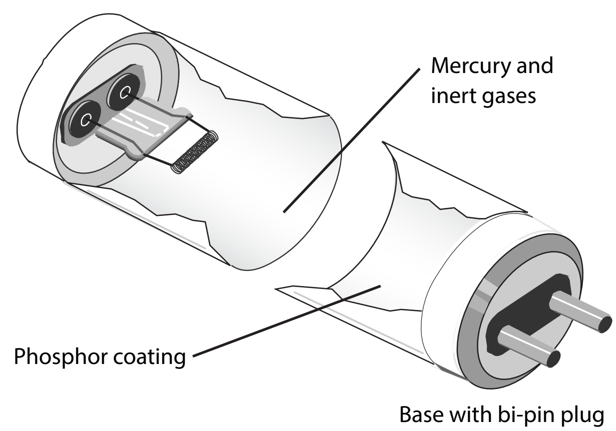
Lighting

Lighting is a significant consumer of energy in a school; about 17 percent of the electricity a school consumes is used to operate the lights. Schools are lit mainly with **fluorescent lights**.

A fluorescent **lamp** is a glass tube, whose inner surface has a powdered phosphor coating. The tube is filled with argon gas and contains a small amount of mercury. At the ends of the tubes are **electrodes**.

An electric **current** is passed from one electrode to the other. When the current passes through the tube, some of the mercury is vaporized and the atoms emit rays of ultraviolet (UV) light. When these invisible UV rays strike the phosphor coating, the phosphor atoms emit visible light. The conversion of one type of light into another is called fluorescence.

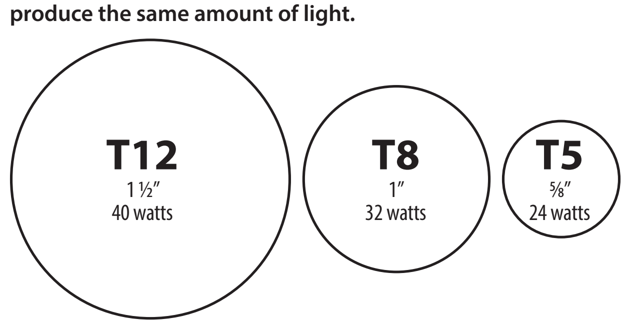
Fluorescent Tube Lamp



In fluorescent tubes, a very small amount of mercury mixes with inert gases to conduct the electric current. This allows the phosphor coating on the glass tube to emit light.

Fluorescent Lighting Efficiency

A T12 bulb consumes up to 40 watts of energy to produce a given amount of light. T8 and T5 bulbs use less energy to produce the same amount of light.



In order to operate, a fluorescent tube needs to have a **ballast** that regulates the electric current passing through the gas inside. There are two types of ballasts, magnetic and electronic.

Magnetic ballasts modulate or adjust the electric current at a frequency of 60 Hertz (Hz), which means the light flickers on and off 60 times a second. Electronic ballasts modulate the current at a much higher frequency of at least 20,000 Hz. Fluorescent lamps run by electronic ballasts are more energy efficient than those run by magnetic ballasts, and they reduce eye strain and other negative health effects experienced by some under older fluorescent lighting systems.

Electronic ballasts use up to 30 percent less energy than magnetic ballasts. Electronic ballasts operate at a very high frequency that eliminates flickering and noise. Some electronic ballasts even allow you to operate the fluorescent lamp on a dimmer switch, which usually is not recommended with most fluorescents. Magnetic ballast manufacture was banned in 2010 for T12 lighting in non-residential settings, but these fixtures may still exist in some schools and buildings, especially in under-utilized areas such as stairwells and hallways.

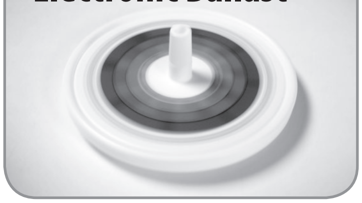
Incandescent lighting is also used in schools. Only 10 percent of the energy consumed by an incandescent bulb produces light; the rest is given off as wasted heat. Fluorescent tubes produce very little heat and are much more energy efficient than incandescent lighting.

Compact fluorescent lights (CFLs) use the same technology as overhead fluorescent tubes, but they are designed to fit into lamps and other fixtures where incandescents are commonly used. All CFLs have electronic ballasts. CFLs can help cut energy costs up to 75 percent and reduce environmental impacts and they last about 10 times longer. Each CFL installed can save $30 to $80 over the life of the bulb. One CFL can reduce carbon dioxide **emissions** by over 100 pounds a year.

Although fluorescent tubes in ceiling fixtures are always more energy efficient than incandescents, there are new, even more efficient fluorescent tubes that use better electrodes and coatings. They produce about the same amount of light with substantially lower wattage.

Most light fixtures in schools use four-foot long tubes, although three-foot tubes are common as well. Older fixtures often contain T12 tubes that are 1-1/2" in diameter and consume 34–40 watts. These tubes can be replaced with energy-saving T8 tubes that are 1" in diameter and typically consume 28–32 watts. Some newer systems are now using T5 tubes that are 5/8" in diameter and are even more efficient than the T8 tubes.

Electronic Ballast



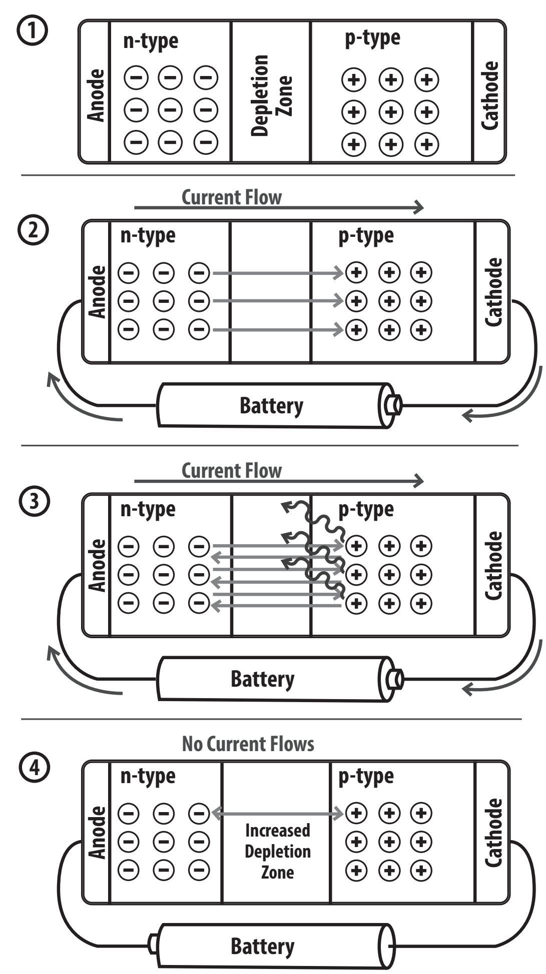
A Flicker Checker

A Flicker Checker is a device for determining whether a tube light has a magnetic or electronic ballast. It can tell the difference between the ballasts because of the difference in the number of times the ballasts switch the current off and on each second. The diagram to the right shows the pattern made by an electronic ballast when the Flicker Checker is spun. It should only be used under flourescent lighting to prevent false readings.

Light emitting diode bulbs are even more efficient than CFL bulbs,

How Light Emitting Diodes Work

1. Diodes are made of semiconductors and conducting materials that need to be added to the semiconductor. In an LED the most common conductor added is aluminum-gallium-arsenide (AlGaAs). The AlGaAs is "doped" by adding small amounts of another material. One material will have more valence electrons than AlGaAs, and another doping material will have fewer electrons. The two doped materials are put together in a crystal. The material with more electrons is the "n-type" (n for negative) and the material with fewer electrons is the "p-type" (p for positive). When these materials are sandwiched together, the electrons move to balance themselves out. The area between the materials, called the p-n junction, is also called the "depletion zone."
2. Connecting a power source to the diode, such as a battery, provides electric current that carries electrical energy. The electrons in the n-type are repelled by the electric current, and move through the depletion zone to the p-type. They are energized, and will want to return to their original, unenergized state in the n-type.
3. When the electrons move back through the depletion zone to the n-type, they release energy as light. This is the light that we see from the LED. This process continues over and over again–electrons absorbing energy, moving, then moving back and releasing the energy, until the power supply is disconnected or depleted.
4. Connecting the power supply in the wrong orientation does not allow the LED to work. Instead, it merely increases the size of the depletion zone. Therefore, it is important that LED's be wired to their power supply in the correct orientation.



last about 25 times longer than incandescent bulbs, and more than times longer than CFLs. One LED bulb has several tiny LEDs inside of it. LEDs contain **semiconductors** like solar panels and other diodes, however the difference is in the way the electrical energy is used by the LED. Three layers within the LED – p-type, n-type, and a **depletion zone** – combine to produce light. Basically, a minimum voltage is needed to energize electrons and they move from the n-layer to the p-layer. When the electrons move back to the n-layer again, they emit light that we see. Read more about this process in the graphic "How Light Emitting Diodes Work" on the previous page.

Although CFLs and LEDs cost more to buy, they save money in the long run because they use 20-25 percent of the energy of incandescent bulbs and last several times longer. Each CFL or LED installed to replace an incandescent can save about $30-80 over the life of each bulb. Replacing incandescent bulbs with LED or CFL bulbs can also reduce carbon dioxide emissions by hundreds of pounds over the life of the bulb.

Exit Signs and Outdoor Lighting

How many exit signs are there in your school? Probably more than you thought. These signs operate all the time, every day of the year. What kinds of lights would you use in these types of fixtures?

Today, high-efficiency lighting is available that uses LEDs. These units consume fewer **watts** of electricity and have a rated lifetime of 25 years. They are perfect for signs, outdoors, and indoors!

You may have noticed that the lights in the parking lot of your school look different than either incandescent or fluorescent lighting. They are likely either pink-orange or blue-green lights. These are high intensity discharge (HID) light fixtures. While the color of the light makes them unsuitable for use in most indoor situations, they are even more efficient than fluorescents. HID lights contain gases that release colored, visible light when stimulated by electrons and ions.

The main difference between HID and fluorescent lighting is that in HID lighting, the gas itself emits the visible light. Most of today's street and parking lot lighting is provided by high-pressure sodium (HPS) lights, containing sodium gas. Sometimes gymnasium lighting is provided by metal halide lights, another type of HID fixture. Even neon signs use this same gas discharge process to create light. Like fluorescents, HID lights require ballasts.

Lighting Controls

Lighting controls are devices that turn lights on and off or dim them. The simplest type is a standard light switch, called a snap switch. Other controls include photocells, timers, occupancy sensors, and **dimmers**. Snap switches, located in convenient areas, make it easier for people in large, shared spaces to turn off lights in unused areas.

Photocells turn lights on and off in response to natural light levels. Photocells switch outdoor lights on at dusk and off at dawn, for example. Advanced designs gradually raise and lower fluorescent light levels with changing daylight levels.

Mechanical or electronic time clocks automatically turn indoor or outdoor lights on and off for security, safety, and tasks such as janitorial work. An **occupancy sensor** activates lights when a person is in the area and turns off the lights after the person has left.

Dimmers reduce the wattage and output of incandescent and fluorescent lamps. Dimmers also significantly increase the service life of incandescent lights. However, dimming incandescent lamps reduces their light output more than their wattage. This makes incandescent lights less efficient as they are dimmed. Dimmers for fluorescents require special dimming ballasts, but do not reduce the efficiency of the lamps.

Lighting: Savings Opportunities

Even the best lighting system isn't efficient if people don't use it wisely. In most schools, more light is used than needed and lights are often left on when no one is using them. Using **daylighting** is a good idea whenever possible. Studies have shown that students learn better in natural light than in artificial light.

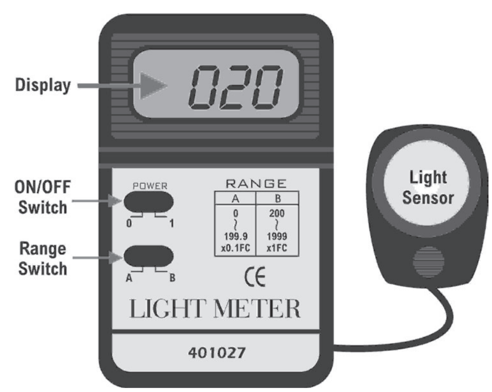
All lights that are not necessary for safety should be turned off when rooms are not in use. The same is true for outside lights. Check to see whether light fixtures have larger diameter T12 tubes or smaller diameter T8 or T5 tubes installed.

Check to see if fixtures are equipped with reflectors or diffusers. Reflectors are installed above the lights to reflect light down to where it is needed. Fixtures that use reflectors often need fewer lights to provide adequate light. Diffusers spread the light over a broader area.

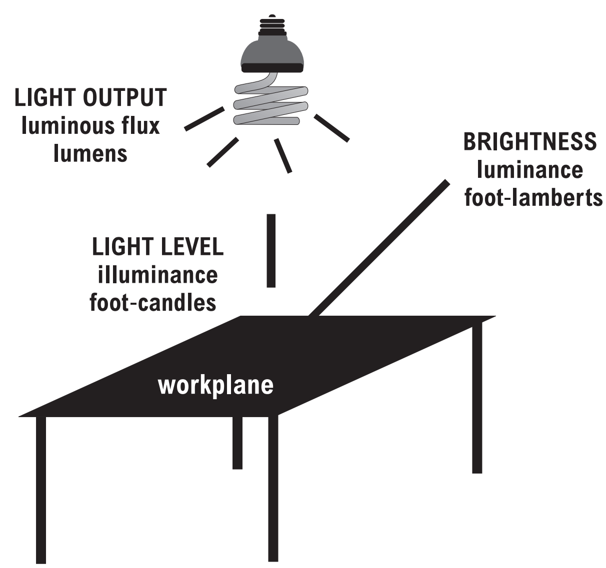
Light Measurement

Use a light meter to determine the light level in a room or area. If light levels are too low, it can cause eyestrain and headaches for

Light Meter



Light Output, Level, and Brightness



those in the room. Low light levels can lead to accidents, as well. If light levels are higher than necessary, then it might be possible to remove some of the tubes in the room, which would save energy.

A **lumen** is a measure of the light output (or luminous flux) of a light source (bulb or tube). Light sources are labeled with output ratings in lumens. A 40-watt T12 fluorescent tube light, for example, may have a rating of 3,050 lumens.

A **foot-candle** (fc) is a measure of the quantity of light (**illuminance**) that actually reaches the workplane on which the light meter is placed. Foot-candles are workplane lumens per square foot. The light meter can measure the quantity of light from 0 to 1,000 fc. Another measure of light is its brightness (or luminance). Brightness is a measure of the light that is reflected from a surface in a particular direction. Brightness is measured in foot-lamberts (fL).

Lighting Survey

Identify locations where incandescent lighting is being used and investigate options for replacing with compact fluorescents or LEDs. Are LED lights being used in exit signs? You may not be able to tell unless they are opened. Ask your building operator to open an exit sign.

Check the lighting controls in the building. Are occupancy sensors in use? If so, are they effective or do they tend to cause problems by shutting off lights when the rooms are being used? High quality occupancy sensors are a good recommendation for energy savings.

Check to see if rooms or spaces are properly lit. Can the lights be controlled so that only some of the lights can be turned on in a room or area? Multiple controls offer the ability to use only the lights needed for different tasks and provide more opportunity for saving. Sometimes natural daylight can be used in part of the room and the lights can be shut off in that area.

Ask building operators if outdoor lighting is controlled by photocells. You can also observe this at dusk and dawn to see if lights are turning on or shutting off.

Finally, check to see if light fixtures are clean. Accumulated dust can reduce light output up to 30 percent.

Recommended Light Levels

Below is a list of recommended illumination levels for school locations in foot-candles.

AREA	FOOT-CANDLES
Classrooms (Reading and Writing)	50
Classrooms (Drafting)	75
Computer Labs (Keyboarding)	30
Computer Labs (Reading Print Materials)	50
Computer Labs (Monitors)	3
Labs-General	50
Labs-Demonstrations	100
Auditorium (Seated Activities)	10
Auditorium (Reading Activities)	50
Kitchens	50
Dining Areas	30
Hallways	20-30
Stairwells	15
Gymnasiums (Exercising and Recreation)	30
Gymnasiums (Basketball Games)	75
Locker Rooms	10
Libraries and Media Centers (Study Areas)	50
Libraries and Media Centers (Other Areas)	30
Shops (Rough Work)	30
Shops (Medium Work)	50
Shops (Fine Work)	75
Offices (Reading Tasks)	50
Offices (Non-Reading Tasks)	30
Teacher Workrooms	30
Conference Rooms	30
Washrooms (Grooming Areas)	30
Washrooms (Lavatories)	15
Maintenance Rooms	30
Building Exteriors and Parking Lots	1-5

Electrical Devices and Appliances

A school building has many electrical devices and **appliances** (called plug loads) that aid in the learning process and help occupants stay comfortable and safe. It's estimated that up to 25 percent of the total electricity consumed by a school is used to power electrical devices. Managing the use of such equipment can greatly reduce a school's electricity consumption.

Look around any classroom and school building and you will see many electrical devices, such as:

- fans
- coffee makers
- microwaves
- televisions
- window air conditioners
- printers and scanners
- copiers
- digital or overhead projectors
- vocational equipment
- refrigerated fountains
- computers/monitors
- laptops/tablets
- desk and table lamps
- refrigerators
- VCRs/DVD players
- vending machines
- fax machines
- fish tanks
- ranges and stoves
- clocks

Most of these devices are important to the learning environment. In addition, there are appliances that teachers and staff bring from home that are not related to teaching, but are routine devices found in any office.

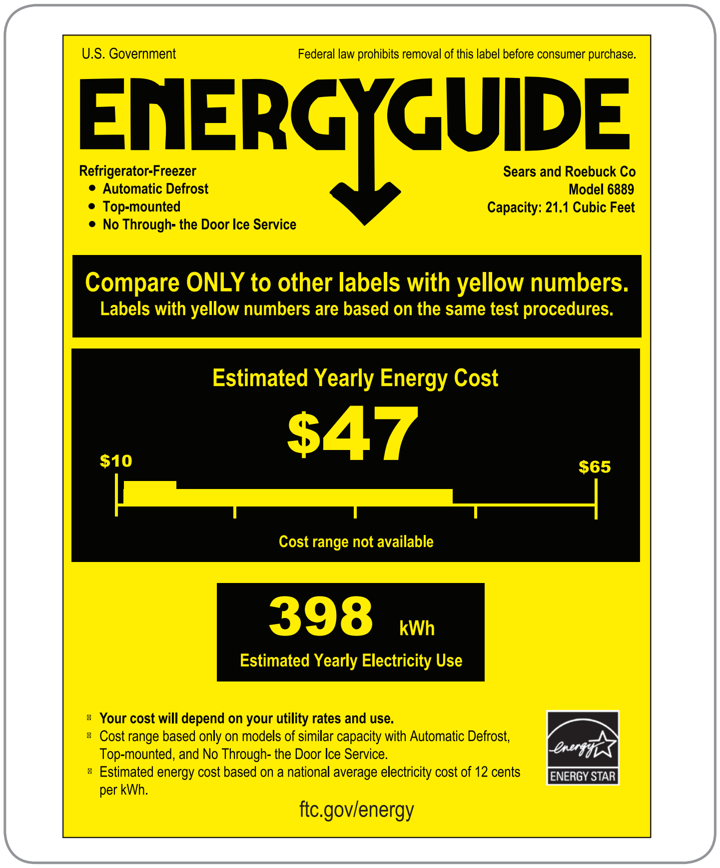
Devices such as computers, printers, and copiers waste energy when they are left on 24 hours a day. Often they are left on as a matter of convenience, because they have long warm–up times. Turning these machines off at the end of the day and turning other machines off when they are not being used can save a lot of energy.

Many computers, TVs, DVD players, digital projectors, and other electrical devices use electricity even when they are turned off. This type of electricity consumption is known as a **phantom load**, because it can easily go unnoticed. Phantom loads are also known as standby power or leaking electricity.

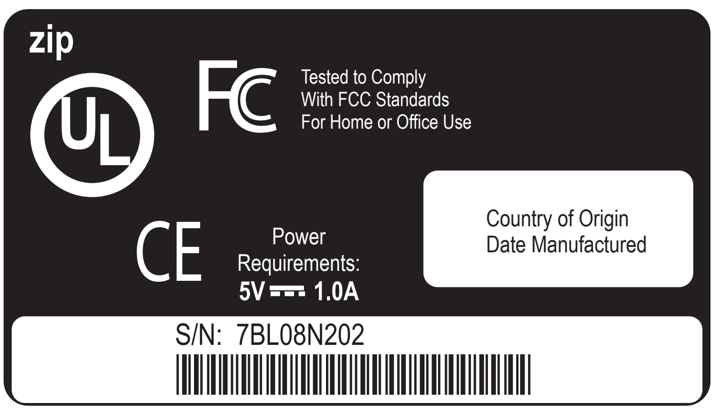
CHANGE FOR THE BETTER WITH ENERGY STAR

Phantom loads exist in many electronic or electrical devices found in schools. Equipment with electronic clocks, timers, or remote controls, portable equipment, and office equipment with wall cubes (small

ENERGYGUIDE LABEL



ELECTRIC NAMEPLATE



box-shaped plugs that plug into AC outlets to power appliances) all have phantom loads. These devices can consume 3–20 watts even when turned off.

Guidelines for Devices

When shopping for a new electrical device or appliance, look for the **ENERGY STAR**® label—your assurance that the product saves energy. ENERGY STAR® appliances have been identified by the U.S. Environmental Protection Agency and Department of Energy as the most energy efficient products in their classes.

A list of these appliances can be found on the ENERGY STAR® website at www.energystar.gov.

Another way to determine which appliance is more energy efficient is to compare energy usage using **EnergyGuide labels**. The Federal Government requires most appliances to display bright yellow and black EnergyGuide labels. Although these labels do not say which appliance is the most efficient, they provide the annual energy consumption and average operating cost of each appliance so you can compare them.

Electrical Devices: Savings Opportunities

Start by looking at the computers in your building. Survey the building's computers after school and see if they are being shut down or left on overnight. Turning computers off at the end of the day saves energy and will not harm the equipment.

Check to see that the computer's power options are set to save energy during periods the computer is on, but not being used. For PCs, click on the "Power Options" icon in the Control Panel. For Macs, click on the Apple logo on the top-left of the screen, click on "System Preferences", and select the "Energy Saver" icon.

Look at all peripherals, such as monitors, printers, scanners, and copiers. Are they set up to go into standby or sleep mode when idle? These should also be shut down at the end of the day. Check for phantom loads. You can use a meter to see if devices are using power when they are turned off. These devices can be plugged into a power strip, which is turned off when the devices are not in use. Common devices with phantom loads include TVs, DVD players, digital projectors, coffee makers, and microwave ovens.

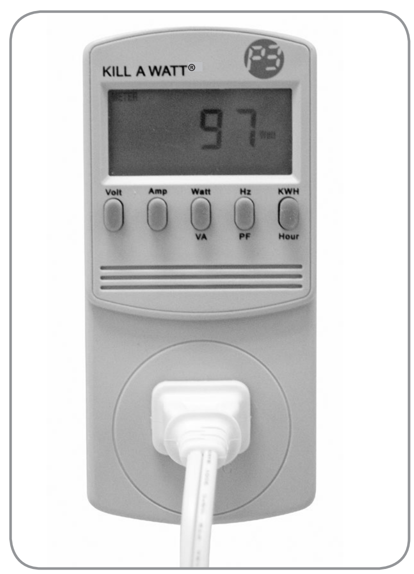
Calculating Electricity Consumption

The amount of electricity consumed by electrical devices can be calculated using a couple of different methods. The first is by looking at the **nameplate** on the device and the second is to measure the consumption directly with the Kill A Watt™ monitor.

Every machine that runs on electricity has an electric nameplate on it. The electric nameplate is usually a sticker or imprint that looks similar to the sample above.

The nameplate has information about the amount of electricity the device uses. Sometimes, the current is listed. The current is measured in **amperes** (A). Sometimes, the voltage the device needs is listed. The voltage is listed in **volts** (V). Sometimes, the wattage is listed. The wattage is measured in watts (W). If the wattage isn't listed, then the current and voltage are both listed. If the wattage isn't listed, you can calculate the wattage using the following formula: W = V x A.

KILL A WATT® MONITOR



During the energy survey, you will be gathering data on electrical appliances by using a meter or obtaining it from the nameplates. A form is provided for recording this information.

A Kill A Watt® monitor is a **watt meter** that can measure and monitor the power consumption of any standard electrical device. Instantaneous readings of voltage (volts), current (amps), line frequency (Hz), and electric **power** being

Digital Thermometer

A digital thermometer measures the temperature of a substance and displays the temperature reading on its face. It has a battery for power. Sometimes they are waterproof for measuring the temperature of a liquid.

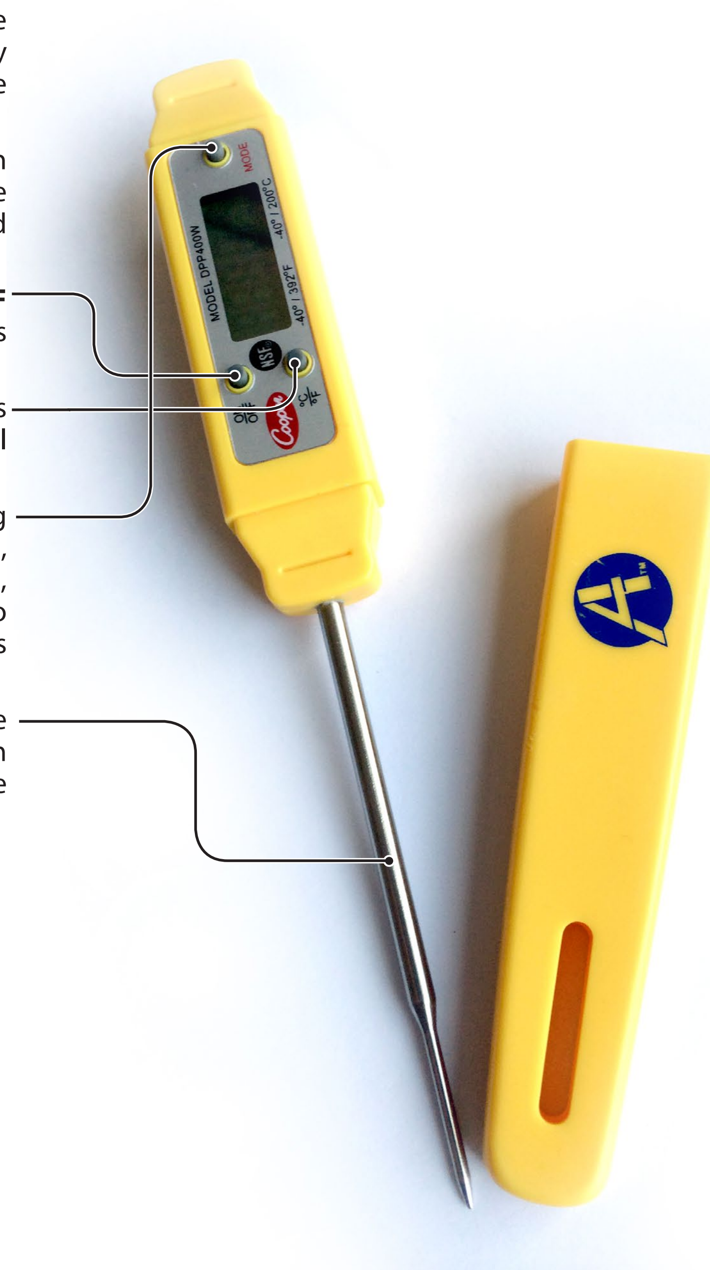
This digital thermometer can measure the temperature in Fahrenheit or Celsius. It shows the temperature range of the thermometer. It can read temperatures from -40° to 392°F and -40° to 200°C.

It has three buttons. The button on the top left is the **ON/OFF** switch. If the thermometer is not used for a few minutes, it turns itself off.

The **C/F** button on the bottom left switches from the Celsius scale to the Fahrenheit scale. The face of the thermometer will show a C or an F to indicate which scale is being used.

The **mode** button on the right holds the temperature reading when it is pushed. If you need the exact temperature of a liquid, you push the hold button while the thermometer is in the liquid, then remove the thermometer to read it. This button will also allow you to view the maximum and minimum temperatures measured when pushed two or three times.

The **metal stem** of the thermometer can measure the temperature of the air or the temperature of a liquid. The stem should be placed about halfway into a liquid to measure the temperature.



Humidity/Temperature Pen

HYGROMETER

Scientists measure the amount of water vapor in the air in terms of relative humidity—the amount of water vapor in the air relative to (compared to) the maximum amount it can hold at that temperature. Relative humidity changes as air temperature changes. The warmer the air is, the more water vapor it can hold.

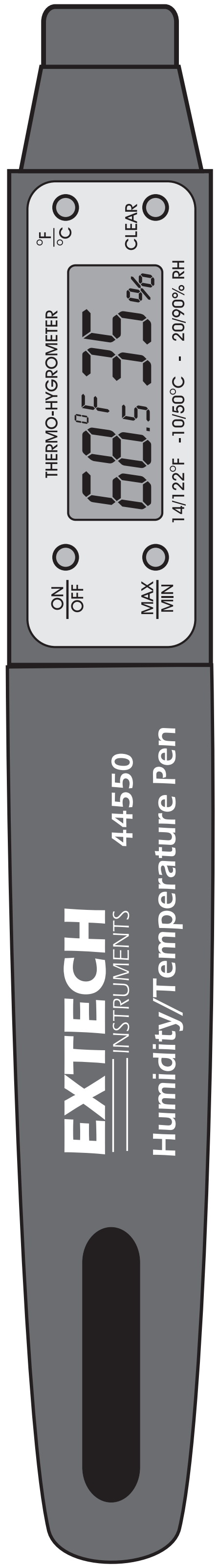
Air acts like a sponge and absorbs water through the process of evaporation. Warm air is less dense and the molecules are further apart, allowing more moisture between them. Cooler air causes the air molecules to draw closer together, limiting the amount of water the air can hold.

It is important to control humidity in occupied spaces. Humidity levels that are too high can contribute to the growth and spread of unhealthy biological pollutants. This can lead to a variety of health effects, from common allergic reactions to asthma attacks and other health problems. Humidity levels that are too low can contribute to irritated mucous membranes, dry eyes, and sinus discomfort.

This digital humidity/temperature pen measures relative humidity and temperature and displays the readings on its face. It has a battery for power. It can display the temperature in Fahrenheit or Celsius. The reading shown on the right is 68.5°F. Devices that measure humidity are also called hygrometers.

The hygrometer displays relative humidity in terms of percentage. The hygrometer shown reads 35%. This means that the air contains 35 percent of the water vapor it can hold at the given air temperature. When the air contains a lot of water vapor, the weather is described as humid. If the air cannot carry any more water vapor, the humidity is 100 percent. At this point, the water vapor condenses into liquid water.

Maintaining relative humidity between 40 and 60 percent helps control mold. Maintaining relative humidity levels within recommended ranges is a way of ensuring that a building's occupants are both comfortable and healthy. High humidity is uncomfortable for many people. It is difficult for the body to cool down in high humidity because sweat cannot evaporate into the air.



Directions

ON/OFF

Press the ON/OFF key to turn the power on or off.

°F/°C

Press the °F/°C key to select the temperature unit you want to use, Fahrenheit or Celsius.

MAX/MIN

Press the MAX/MIN key once to display the stored maximum readings for temperature and humidity.

An up arrow will appear on the left side of the display to indicate the unit is in the maximum recording mode.

Press the MAX/MIN key a second time to display the stored minimum readings for temperature and humidity. A down arrow will appear on the left side of the display to indicate the unit is in the minimum recording mode.

Press the MAX/MIN key a third time to return to normal operation.

CLEAR

If an up or down arrow is displayed, press the CLEAR key until - - - appears on the display. The memory is cleared. New maximum or minimum values will be recorded within 3 seconds.

Kill A Watt® Monitor Instructions

Kill A Watt® Monitor

The Kill A Watt® monitor allows users to measure and monitor the power consumption of any standard electrical device. You can obtain instantaneous readings of voltage (volts), current (amps), line frequency (Hz), and electric power (watts) being used. You can also obtain the actual amount of power consumed in kilowatt-hours (kWh) by any electrical device over a period of time from 1 minute to 9,999 hours. One kilowatt equals 1,000 watts.

Operating Instructions

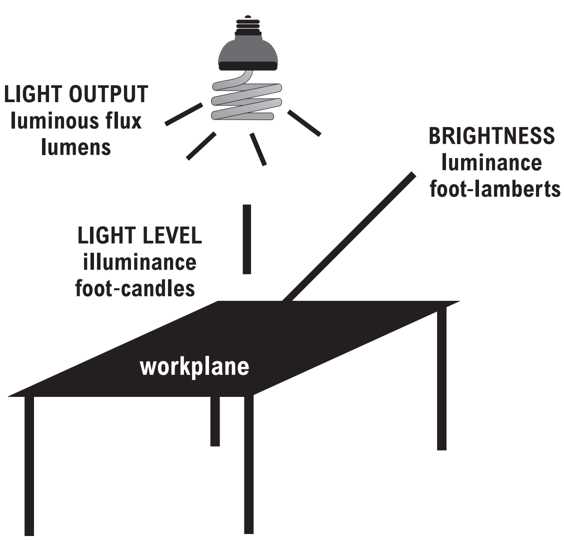
1. Plug the Kill A Watt® monitor into any standard grounded outlet or extension cord.
2. Plug the electrical device or appliance to be tested into the AC Power Outlet Receptacle of the Kill A Watt® monitor.
3. The LCD displays all monitor readings. The unit will begin to accumulate data and powered duration time as soon as the power is applied.
4. Press the Volt button to display the voltage (volts) reading.
5. Press the Amp button to display the current (amps) reading.
6. The Watt and VA button is a toggle function key. Press the button once to display the Watt reading; press the button again to display the VA (volts x amps) reading. The Watt reading, not the VA reading, is the value used to calculate kWh consumption.
7. The Hz and PF button is a toggle function key. Press the button once to display the Frequency (Hz) reading; press the button again to display the power factor (PF) reading.
8. The KWH and Hour button is a toggle function key. Press the button once to display the cumulative energy consumption; press the button again to display the cumulative time elapsed since power was applied.

What is Power Factor (PF)?

We often use the formula **Volts x Amps = Watts** to find the energy consumption of a device. Many AC devices, however, such as motors and magnetic ballasts, do not use all of the power provided to them. The **power factor** (PF) has a value equal to or less than one, and is used to account for this phenomenon. To determine the actual power consumed by a device, the following formula is used:

Volts x Amps x PF = Watts Consumed

The Light Meter



Operating Instructions

1. Insert the battery into the battery compartment in the back of the meter.
2. Slide the ON/OFF Switch to the ON position.
3. Slide the Range Switch to the B position.
4. Place the meter on a flat surface in the area you plan to measure.
5. Hold the Light Sensor so that the white lens faces the light source to be measured or place the Light Sensor on a flat surface facing the direction of the light source.
6. Read the measurement on the LCD Display.
7. If the reading is less than 200 fc, slide the Range Switch to the A position and measure again.

Light Output or Luminous Flux

A lumen (lm) is a measure of the light output (or luminous flux) of a light source (bulb or tube). Light sources are labeled with output ratings in lumens. A T12 40-watt fluorescent tube light, for example, may have a rating of 3050 lumens.

Light Level or Illuminance

A foot-candle (fc) is a measure of the quantity of light (illuminance) that actually reaches the workplane on which the light meter is placed. Foot-candles are workplane lumens per square foot. The light meter can measure the quantity of light from 0 to 1000 fc.

Brightness or Luminance

Another measure of light is its brightness or luminance. Brightness is a measure of the light that is reflected from a surface in a particular direction. Brightness is measured in foot-lamberts (fL).

Flicker Checker

The most important difference between incandescent and fluorescent light bulbs is the process by which they produce light. Incandescent bulbs produce light by passing current through a wire. The wire, often made of tungsten, is a resistor. A resistor is a device that turns electrical energy into heat and light energy.

The wire inside an incandescent light bulb is a special type of resistor called a filament. Many incandescent bulbs have clear glass so you can see the filament. In addition to the wire, the bulb contains a gas called argon. The argon gas helps the bulb last longer. If the wire were exposed to air, it would oxidize and the wire would burn out faster. The argon does not react with the metal like air does. The argon also helps the filament be a better resistor—it actually helps it produce more light than air would. Resistors emit more heat than light. In an incandescent light bulb, 90 percent of the energy from the electricity is turned into heat and only 10 percent of the energy is turned into light.

A fluorescent bulb produces light differently. It produces light by passing an electric current through a gas to ionize it. The electrons in the molecules of gas become excited because of the electrical energy and emit photons of UV light. They bounce around and crash into the walls of the tube. The walls of the tubes are painted with a coating that converts the UV light into visible light. If you have ever seen the inside of a fluorescent tube, the glass is coated with white powdery material. This powder is what fluoresces (gives off visible light).

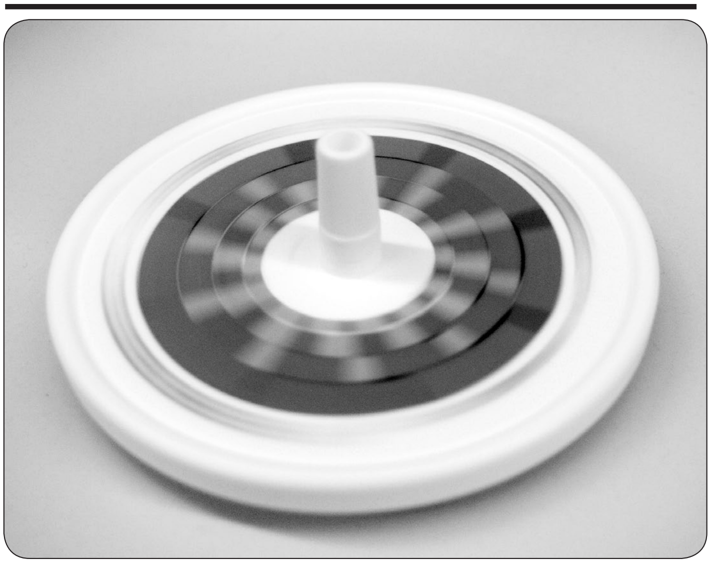
The part of a fluorescent light bulb that sends and controls the current through the gas is called a ballast. There is a part of the ballast at each end of the tube. The ballast is an electromagnet that can produce a large voltage between the two parts. It is this voltage that gives the electrons of the gas molecules the energy inside the tube.

A magnetic ballast has an iron ring wrapped with hundreds of coils of wire. The current from the electrical outlet runs through the wire in the ballast. The wire also is a resistor to some degree, so there is some heat produced. There is also a little heat given off by the gas. A fluorescent bulb with a magnetic ballast converts about 40 percent of the electricity into light and 60 percent into heat.

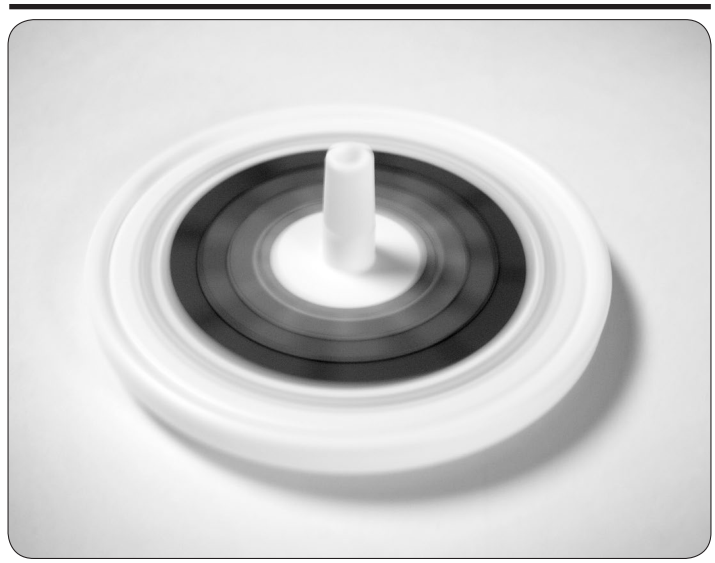
An electronic ballast has a microchip, like that found in a computer, instead of the coils of wire. This ballast is about 30 percent more efficient in turning electrical energy into light than a magnetic ballast. Some heat is produced in the gas, but not in the ballast itself.

The reason that the Flicker Checker can tell the difference between the magnetic and electronic ballasts is because of the way the current is delivered to the gas. In any outlet in the United States that is powered by an electric company, the electricity is sent as alternating current—it turns on and off 60 times each second. Because the light with the magnetic ballast has wires attached to the outlet, it also turns on and off 60 times per second, a lower frequency. The microchip in the electronic ballast can change that frequency. Light bulbs with electronic ballasts are made to turn on and off between 10,000 and 20,000 times each second.

MAGNETIC BALLAST



ELECTRONIC BALLAST



Cost of Using Electrical Devices

Calculate how much it costs to operate the machines in your classroom that you looked at before. You need to know the wattage, the cost of electricity, and the number of hours a week each machine is used.

You can estimate the number of hours the machine is used each week, then multiply by 40 to get the yearly use. We are using 40 weeks for schools, because school buildings aren't used every week of the year. Using the copier as an example, if it is used for ten hours each week, we can find the yearly use like this:

Yearly use = 10 hours/week x 40 weeks/year = 400 hours/year

Remember that electricity is measured in kilowatt-hours. You will need to change the watts to kilowatts. One kilowatt is equal to 1,000 watts. To get kilowatts, you must divide the watts by 1,000. Using the copier as an example, divide like this:

kW = W/1,000

kW = 1,265/1,000 = 1.265

The average **cost of electricity for commercial buildings or schools in the U.S. is about ten cents ($0.10)** a kilowatt-hour. You can use this rate or find out the actual rate from your school's electric bill. Using the average cost of electricity, we can figure out how much it costs to run the copier for a year by using this formula:

Yearly cost	**=**	**Hours used**	**x**	**Kilowatts**	**x**	**Cost of electricity (kWh)**			
Yearly cost	**=**	**400 hours/year**	**x**	**1.265 kW**	**x**	**$0.10/kWh**			
Yearly cost	**=**	**400**	**x**	**1.265**	**x**	**$0.10**	**=**	**$50.60**	

MACHINE OR APPLIANCE	HOURS PER WEEK	HOURS PER YEAR	WATTS (W)	KILOWATTS (kW)	RATE ($/kWh)	ANNUAL COST
Copier	*10*	*400 hours*	*1,265 W*	*1.265 kW*	*$0.10*	*$50.60*

Environmental Impacts

When we breathe, we produce carbon dioxide. When we burn fuels, we produce carbon dioxide too. Carbon dioxide (CO_2) is a greenhouse gas. Greenhouse gases hold heat in the atmosphere. They keep our planet warm enough for us to live, but since the Industrial Revolution we have been producing more carbon dioxide than ever before. Since 1850, the level of CO_2 in the atmosphere has increased more than 44 percent.

Research shows that greenhouse gases are trapping more heat in the atmosphere. Scientists believe this is causing the average temperature of the Earth's atmosphere to rise. They call this global climate change or global warming. Global warming refers to an average increase in the temperature of the atmosphere, which in turn causes changes in climate. A warmer atmosphere may lead to changes in rainfall patterns, a rise in sea level, and a wide range of impacts on plants, wildlife, and humans. When scientists talk about the issue of climate change, their concern is about global warming caused by human activities.

Driving cars and trucks produces carbon dioxide because fuel is burned. Heating homes by burning natural gas, wood, heating oil, or propane produces carbon dioxide too.

Making electricity can also produce carbon dioxide. Some energy sources—such as hydropower, solar, wind, geothermal, and nuclear—do not produce carbon dioxide, because no fuel is burned. About 38.64 percent of our electricity, however, comes from burning coal. Another 30.12 percent comes from burning natural gas, petroleum, and biomass.

On average, every kilowatt-hour of electricity produces 1.23 pounds of carbon dioxide. Let's use this rule to figure out how much carbon dioxide is produced by the machines and electrical devices in your classroom. You can put the figures from the earlier worksheets in the boxes below. Here are the figures for the copier:

CO_2 a year = wattage x hours of use = rate of CO_2/kWh = total pounds of CO_2 per year

CO_2 a year = 1.265 kW x 400 hr/yr x 1.23 lb/kWh = 622.38 lbs/year

MACHINE OR APPLIANCE	KILOWATTS (kW)	HOURS PER YEAR	ANNUAL kWh	RATE OF CO_2/kWh	ANNUAL CO_2 PRODUCED
Copier	*1.265 kW*	*400 hours*	*506 kWh*	*1.23 lbs/kWh*	*622.38 lbs/yr*

Lighting Options

Ten years ago, we used a lot of energy in the form of electricity to make light to be able to see. Thirty percent of the electricity schools used was for lighting, and homes used about 14 percent of their electricity consumption for lighting. That's because homes, schools, and other commercial buildings used a lot of incandescent lighting. These inefficient bulbs were perfected by Thomas Edison in 1879 and didn't change much for the next 125 or more years! These bulbs were surprisingly inefficient, converting up to 90 percent of the electricity they consumed into heat.

The Energy Independence and Security Act of 2007 changed the standards for the efficiency of light bulbs used most often. As of 2014, most general use bulbs must be 30 percent more efficient than traditional, inefficient incandescent bulbs. What do the new standards mean for consumers? The purpose of the new efficiency standards is to give people the same amount of light using less energy. Most incandescent light bulbs have since been phased out and are no longer available for sale. This has resulted in significant energy savings for homes and schools. Newer, efficient lighting now accounts for only 17 percent of the electricity used in schools, and eleven percent used in homes.

There are several lighting choices on the market that meet the new efficiency standards. Energy-saving incandescent, or halogen, bulbs are different than traditional, inefficient incandescent bulbs because they have a capsule around the filament (the wire inside the bulb) filled with halogen gas. This allows the bulbs to last three times longer and use 25 percent less energy.

Compact fluorescent light bulbs (CFLs) provide the same amount of light as incandescent bulbs, but use up to 75 percent less energy and last ten times longer. CFLs produce very little heat. Using CFLs can help cut lighting costs and reduce environmental impacts. Today's CFL bulbs fit almost any socket, produce a warm glow and, unlike earlier models, no longer flicker and dim. CFLs have a small amount of mercury inside and should always be recycled rather than thrown away. Many retailers recycle CFLs for free.

Light emitting diodes, better known as LEDs, are gaining in popularity. Once used mainly for exit signs and power on/off indicators, improved technology and lower prices are enabling LEDs to be used in place of incandescents and CFLs. LEDs are one of the most energy-efficient lighting choices available today. LEDs use 75 percent less energy than traditional incandescents, and have an average lifespan of at least 25,000 hours. The cost of LEDs has dropped in the last five years and may continue to drop. They use even less energy than CFLs, save more electricity, and produce fewer carbon dioxide emissions. The U.S. Department of Energy estimates that widespread adoption of LED lighting by 2027 would reduce lighting electricity demand by 33 percent. This would avoid construction of 40 new power plants.




	INCANDESCENT BULB	HALOGEN	COMPACT FLUORESCENT (CFL)	LIGHT EMITTING DIODE (LED)
Brightness	850 lumens	850 lumens	850 lumens	850 lumens
Life of Bulb	1,000 hours	3,000 hours	10,000 hours	25,000 hours
Energy Used	60 watts = 0.06 kW	43 watts = 0.043 kW	13 watts = 0.013 kW	12 watts = 0.012 kW
Price per Bulb	$0.50	$3.00	$3.00	$8.00

Comparing Light Bulbs

The graphic on the previous page shows four light bulbs that produce the same amount of light. You might use bulbs like these as a bright overhead light. One bulb is an incandescent light bulb (IL), one is a halogen, one is a compact fluorescent light (CFL), and another is a light emitting diode (LED). Which one is the better bargain? Let's do the math and compare the four light bulbs **using the commercial cost of electricity at $0.10/kWh.**

1. Determine how many bulbs you will need to produce 25,000 hours of light by dividing 25,000 by the number of hours each bulb produces light.
2. Multiply the number of bulbs you will need to produce 25,000 hours of light by the price of each bulb. The cost of each bulb has been given to you.
3. Multiply the wattage of the bulbs (using the kW number given) by 25,000 hours to determine kilowatt-hours (kWh) consumed.
4. Multiply the number of kilowatt-hours by the cost per kilowatt-hour to determine the cost of electricity to produce 25,000 hours of light.
5. Add the cost of the bulbs plus the cost of electricity to determine the life cycle cost for each bulb. Which one is the better bargain?
6. Compare the environmental impact of using each type of bulb. Multiply the total kWh consumption by the average amount of carbon dioxide produced by a power plant. This will give you the pounds of carbon dioxide produced over the life of each bulb. Which one has the least environmental impact?




All bulbs provide about 850 lumens of light.

	COST OF BULB	INCANDESCENT BULB	HALOGEN	COMPACT FLUORESCENT (CFL)	LIGHT EMITTING DIODE (LED)
	Life of bulb (how long it will light)	1,000 hours	3,000 hours	10,000 hours	25,000 hours
	Number of bulbs to get 25,000 hours				
x	Price per bulb	$0.50	$3.00	$3.00	$8.00
=	**Cost of bulbs for 25,000 hours of light**				
	COST OF ELECTRICITY	**INCANDESCENT BULB**	**HALOGEN**	**COMPACT FLUORESCENT (CFL)**	**LIGHT EMITTING DIODE (LED)**
	Total Hours	25,000 hours	25,000 hours	25,000 hours	25,000 hours
x	Wattage	60 watts = 0.060 kW	43 watts = 0.043 kW	13 watts = 0.013 kW	12 watts = 0.012 kW
=	Total kWh consumption				
x	Price of electricity per kWh	$0.10	$0.10	$0.10	$0.10
=	**Cost of Electricity**				
	LIFE CYCLE COST	**INCANDESCENT BULB**	**HALOGEN**	**COMPACT FLUORESCENT (CFL)**	**LIGHT EMITTING DIODE (LED)**
	Cost of bulbs				
+	Cost of electricity				
=	**Life cycle cost**				
	ENVIRONMENTAL IMPACT	**INCANDESCENT BULB**	**HALOGEN**	**COMPACT FLUORESCENT (CFL)**	**LIGHT EMITTING DIODE (LED)**
	Total kWh consumption				
x	Pounds (lbs) of carbon dioxide per kWh	1.23 lb/kWh	1.23 lb/kWh	1.23 lb/kWh	1.23 lb/kWh
=	**Pounds of carbon dioxide produced**				

Reading an Electric Meter

An electric company sends electricity to your home or school through a power line. There is a meter at the school to measure the amount of electricity the school uses.

Reading an electric meter is easy. The face of the meter has five dials with the numbers 0 through 9 on each dial. The dials are not alike. On the first dial, the numbers are in a clock-wise direction. On the next meter, the numbers are in the opposite direction, in a counter clock-wise direction. The dials change from clock-wise to counter clock-wise, as shown below. If the pointer is between two numbers, you always record the smaller number. If the pointer is between 9 and 0, record 9, since 0 represents 10 in this instance. Here are two examples with the correct numbers below the dials:

On Monday morning, this was the electric meter reading:

4 0 5 6 5

The total reading is 40,565

On Friday afternoon, this was the electric meter reading:

4 1 6 1 5

The total reading is 41,615

How much electricity was used this week? **Subtract Monday's reading from Friday's reading**:

Friday – Monday = Electricity used

41,615 – 40,565 = 1,050 kilowatt-hours

The electricity is measured in kilowatt-hours. If the power company charges a **school** the **commercial rate** of ten cents ($0.10) for every kilowatt-hour (kWh) of electricity that is used, what is the cost of the electricity that was used during the week?

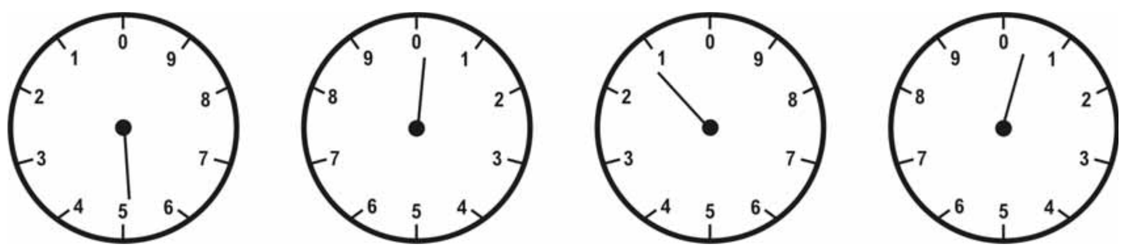
____________ **kWh X $0.10/kWh = $** ____________________

Reading a Natural Gas Meter

A gas company delivers natural gas to a school through an underground pipeline. There is a meter at the school to measure the volume of natural gas that the school uses.

Reading a natural gas meter is much like reading an electric meter. The face of the meter has four dials with the numbers 0 through 9 on each dial. Notice that the dials are not alike. On two dials the numbers are in a clock-wise direction. On the other two, the numbers are in a counter clock-wise direction. Each dial changes from clock-wise to counter clock-wise, as shown below. If the pointer is between two numbers, you always record the smaller number. If the pointer is between 9 and 0, record 9, since 0 represents 10 in this instance. Here are two examples with the correct numbers below the dials:

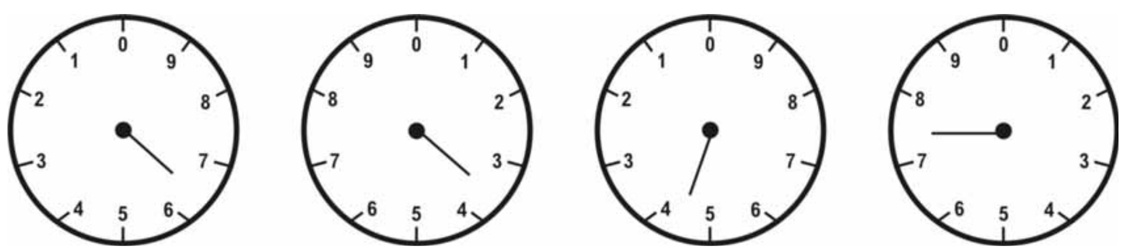
On December 1, this was the natural gas meter reading:



5 0 1 0

The total reading is 5,010

On January 1, this was the natural gas meter reading:



6 3 4 7

The total reading is 6,347

How much gas was used in December? Subtract the December 1st reading from the January 1st reading:

January 1 – December 1 = Electricity used

6,347 – 5,010 = 1,337 Ccf

Natural gas is measured in Cf or cubic feet—a measure of its volume. A cubic foot of natural gas is not much fuel, so most gas meters measure natural gas in hundreds of cubic feet—or Ccf. The gas company measures the natural gas in Ccf, but it charges by the amount of heat or thermal energy in the gas. The thermal energy is measured in therms.

One Ccf of natural gas contains about one therm of heat (1.030 therms in 2014). If the gas company charges $0.89 for a Ccf of gas, **the national average for commercial customers** in 2014, how much did the gas cost for December?

Cost = ____________ therm X $0.89/Ccf = $ ________________

Sample Bill Explanation Key

Sample School Electric Bill Explanation

1. Bill Mailing Date
2. Customer Account Number
3. Payment Due Date
4. Total Amount Due
5. Meter Readings By Date in Kilowatt-hours (Note that there are two meters on this bill)
6. Actual Kilowatt-hours Consumed
7. Cost of the Electricity Consumed
8. Sales and Use Surcharge
9. Total Current Charges
10. Demand— a measurement of the rate at which electricity is used. The monthly demand is based on the 15 minutes during a billing period with the "highest average" kW use. Demand charges are designed to collect some of the generation and transmission-related costs necessary to serve a particular group or class of customers.
11. Actual Demand for the meter
12. Schedule 130. A rate class that determines how much is paid per kWh of usage and kW demand.
13. Electricity Supply Service. Customers are billed for the electricity supply and the delivery of the electricity. The supply charge reflects the cost of generating the electricity at the power plant.
14. Distribution Service. The delivery charge reflects the cost of delivering the electricity from the power plant to the customer.

Sample School Natural Gas Bill Explanation

1. Customer Account Number
2. Date of the Bill
3. Date of Next Meter Reading
4. Date of the Next Bill
5. Last Payment Received
6. Charge for Delivering the Natural Gas to the School
7. Charge for the Natural Gas
8. Total Amount Due
9. Comparison of Heating Degree Days. Degree day is a quantitative index that reflects demand for energy to heat or cool buildings. This index is derived from daily temperature observations at nearly 200 major weather stations in the contiguous United States. The heating year during which heating degree days are accumulated extends from July 1st to June 30th. A mean daily temperature (average of the daily maximum and minimum temperatures) of 65°F is the base for both heating and cooling degree day computations. Heating degree days are summations of negative differences between the mean daily temperature and the 65°F base.
10. Graph of Actual Gas Used by Month for the Last Year
11. The Actual Meter Readings for the Month
12. The Volume of Gas Used in CCF
13. The Meter Number
14. EnergyShare Fund. Most utilities are associated with a fuel fund for needy customers; paying customers can contribute any amount to the fund and note it here.
15. Due Date of Payment
16. Amount Enclosed by Customer

Sample School Electric Bill

Nov 27, 2014 1

Customer Bill
ABC Elementary School
Anytown, USA

Your Electric Company

Billing and Payment Summary

Account # 000-1234 2 **Due Date: Jan 02,2015** 3
Total Amount Due: $ 7,462.61 4

To avoid a Late Payment Charge of 1.5% please pay by Jan 02, 2015

Previous Amount Due:	$ 8,152.93
Payments as of Nov 27:	$ 8,152.93

Meter and Usage | **Usage History**

Current Billing Days: 34

Billable Usage

Schedule 130	*10/23 - 11/26*	12
Total kWh	12192	
Dist Demand	61.0	10
Demand	57.0	
Schedule 130	*10/23 - 11/26*	
Total kWh	69888	
Dist Demand	272.0	10
Demand	259.0	

Measured Usage 5

Meter: 000-1234	*10/23 - 11/26*	
Current Reading	4147	
Previous Reading	4020	
Total kWh	12192	6
Current Reading	.60	
Demand	57.60	11
Multiplier: 96		
Meter: 111-4567	*10/23 - 11/26*	
Current Reading	51746	
Previous Reading	51382	
Total kWh	69888	6
Current Reading	1.35	
Demand	259.20	11
Multiplier: 192		

Explanation of Bill Detail

Your Electric Company 1-800-123-4567

	Previous Balance	8,152.93	
	Payment Received	8,152.93	
	BALANCE FORWARD	0	
	Non-Residential Service (Schedule 130)	*10/23 - 11/26*	
	Distribution Service		
	Basic Customer Charge	86.52	
	Distribution Demand	206.29	
13	Electricity Supply Service (ESS)		
	ESS Adjustment Charge	83.93 CR	
	Electricity Supply kWh	214.94	
	ESS Demand Charge	558.85	7
	Fuel Charge	353.81	
	Sales and Use Surcharge	2.68	8
	Non-Residential Service (Schedule 130)	*10/23 - 11/26*	
14	Distribution Service		
	Basic Customer Charge	86.52	
	Distribution Demand	919.87	
	Electricity Supply Service (ESS)		
	ESS Adjustment Charge	374.243 CR	
	Electricity Supply kWh	909.41	
	ESS Demand Charge	2,539.36	7
	Fuel Charge	2,058.15	
	Sales and Use Surcharge	13.38	8
	TOTAL CURRENT CHARGES	7,463.61	9
	TOTAL ACCOUNT BALANCE	7,463.61	4

For service emergencies and power outages, call 1-800-123-4567.

Mailed on Nov 28, 2014

Please detach and return this payment coupon with your check made payable to Your Electric Company.

Payment Coupon

Bill Date Nov 27, 2014 1

Please Pay by 01/02/ 2015 3
$ 7,463.54 4

Amount Enclosed

Account # 000-1234 2

Send payment to:

ABC Elementary School
123 Main Street
Anytown, USA 98765

Your Electric Company
PO BOX 123456
Anytown, USA 98765

01166005000 000000009368 6868686 0001234 11272007

Sample School Natural Gas Bill

ABC Elementary School
Anytown, USA

NOTE: The bill you received on or around Friday, Nov. 2 was calculated using estimated usage instead of the actual meter reading. This invoice reflects your actual meter reading. If your new amount due is more than what was indicated on your previous bill, please remit payment for the difference. If it is less, and you've already paid, the difference will be credited to your account and shown on your next bill. We apologize for the inconvenience.

1 Account Number	2 Billing Date	3 Next Meter Reading	4 Next Billing Date
000-12345678	Nov 15, 2014	Dec 3, 2014	Dec 4, 2014

Visit our web site at www. yourgascompany.com

If you have any questions call 1-800-000-0000

Credits & Charges Since Your Last Bill

Payments Received - Thank You	$1,302.60 CR	5
Outstanding Balance	$0.00	

Current Charges

General Service

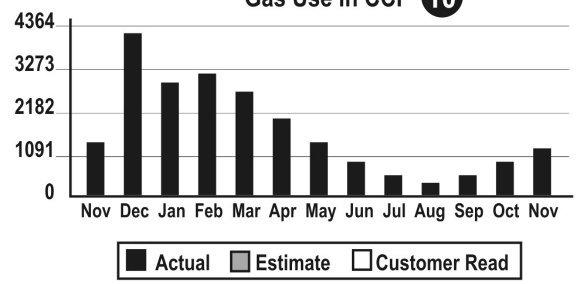
Delivery	6	282.14
Gas Supply	7	1,377.91
Total Current Charges		**$1,660.05**
Total Account Balance	8	**$1,660.05**

For Gas Leaks, call 1-800-123-4567

Monthly Usage Comparison

Heating Degree Days For This Billing Period	2013	9	2014	NORMAL
	160		51	138

Gas Use in CCF 10



Billing Period and Meter Readings

Date	Read Type	Reading
October 30, 2014	Actual	70320
October 01, 2014	Actual	68985

11

CCF used in 29 days: 1335 12
Meter Number 123456 13

Please pay by Dec 10, 2014 , To Avoid A Late Charge of 1.5% Per Month

EnergyShare has helped customers pay heating bills of all kinds. You can help by adding $1, $2, $5, $10, $15, or $20 to your gas bill payment. 14

Please make checks payable to Your Gas Company and return this portion with your payment. Thanks!

YOUR GAS COMPANY
PO Box 123456 Anytown, USA 98765

PREVIOUS BALANCE	**$0.00**	
Total Current Charges	**$1,660.05**	**Pay By Dec 10, 2014** 15
Total Account Balance	**$1,660.05**	
Account # 000-12345678	Amount Enclosed	16

ABC Elementary School
123 Main Street
Anytown, USA 98765

Your Gas Company
PO BOX 123456
Anytown, USA 98765

0116600500000000000009368686868600012345678

Conducting an Energy Survey

Become an Energy Surveyor

We usually don't think about the energy we use every day. The devices we rely on to provide heat, light, and other services are usually in the background, but we are literally surrounded by them. Usually, the only times we notice them are when they are not working as they should.

Conducting an energy survey of a building requires us to notice all of the energy–consuming equipment that we usually ignore. It takes the mindset of a scientist and an analyst to carefully observe and record the information needed to paint a picture of how a building is using energy.

There are several steps to conducting an energy analysis:

1. Interviewing building occupants;
2. Gathering data;
3. Analyzing data; and
4. Making recommendations.

Interviewing Building Occupants

A lot can be determined about a building's energy consumption through direct observation and the information procured by talking with those who work in the building. The first step of the survey will be to interview one or more school staff members. You will design these interviews, conduct them, and record the responses.

Preparing and Interviewing

1. Assign roles for all team members: designer, interviewer, and recorder.
2. Identify the school staff you plan to interview and their contact information.
3. Use the lists on the following page to prepare a draft list of interview questions.
4. If necessary, prepare a script for use in the interview, including the purpose of the interview.
5. Review your draft list of questions and interview script with your teacher.
6. Contact the staff and arrange appointments for the interviews, allowing for a 30–minute time slot.
7. Ask the staff persons interviewed if you may schedule a follow-up interview. You may have further questions after gathering data.

Processing the Data

1. Work with your teacher and team to identify any positive and negative findings.
2. Identify any areas where data is still missing. Identify data that you will need to gather when surveying the building.
3. Prepare additional questions, if necessary, and conduct follow-up interviews.

Reporting Your Findings and Recommendations

1. The final results of these interviews will be used along with the data gathered through measurement and observation to develop an Energy Action Plan.
2. The results might also indicate changes in or additions to existing equipment that would help to conserve energy, such as timers, dimmers, sensors, programmable thermostats, compact fluorescent lights, etc.
3. Your findings and recommendations report may take many forms, including a written report with charts and graphs, a multimedia presentation, posters, or a video project.

Tips for Developing Questions

Areas of interest in the design of staff interviews:

▪How aware are staff of their spaces and the devices or systems that use energy?

▪How familiar are staff with controls such as thermostats and energy saving settings for equipment?

▪What are their patterns of use regarding these devices and systems?

▪What are their feelings and opinions about energy use and energy efficiency?

▪Are they aware of any energy waste in their work environment? What are they?

▪Are they familiar with energy conservation practices? What are they?

▪Are they employing any energy conservation practices? Which practices?

Types of energy consuming systems and devices:

▪Climate control; heating, air conditioning, ventilation

▪Lighting; natural lighting, overhead lighting, task lighting

▪Business machines; copiers, projectors, printers

▪Computers; desktop, laptop, accessories

▪Miscellaneous plug loads; pencil sharpeners, chargers, adapters

▪Anything specific to the staff person (i.e., cafeteria refrigerator, gym exercise machines)

Gathering and Analyzing Data

Use the *Data Forms* on the following pages to record information about the space you are analyzing. The forms are broken into the following sections with a listing of the equipment needed for each section:

▪Building Envelope: Digital Thermometer, Digital Humidity/Temperature Pen

▪HVAC: Digital Thermometer, Digital Humidity/Temperature Pen

▪Lighting: Flicker Checker, Light Meter

▪Electrical Devices: Kill A Watt® Monitor

In addition to gathering your data, keep in mind that you are interested in learning how efficient your building is. While you are gathering your data, use the *Observation Data Form* to record your observations and thoughts about energy usage in the school. For each location, note every incidence in which energy was being used and list it on the form. If you believe that energy is being used efficiently, the observation should be listed in the right hand section (+) of the form. If you believe that energy is being used inefficiently, list it on the left hand section (—) of the form.

An example might be if you entered a classroom not being used at the time of your visit. If the lights in the room were on even though no one was in the room, it would be listed on the left hand section (—) of the form.

After completing your analysis of the costs and environmental impacts of using electrical appliances, review your *Observation Data Form* to see if your results here provide you with more information to include there. During your energy survey, you may have observed other areas where energy was being used efficiently and areas where it was not being used efficiently. Note these on your form.

OBSERVATION DATA FORM

−		+	
LOCATION	**OBSERVATION**	**LOCATION**	**OBSERVATION**

BUILDING ENVELOPE DATA FORM

Age of Building	
Type of Construction	
Number of Floors/Wings	
Orientation	
Landscaping	
Weather	
Outdoor Temperature	
Outdoor Relative Humidity	
Room Temperature	
Room Relative Humidity	
Windows Open or Closed?	
Doors Open or Closed?	
Direction Windows Face	
Windows Cracked or Broken?	
Windows Single or Double Paned?	
Can Windows Be Opened?	
Do Windows Leak Air?	
Adjustable Blinds?	
Number of Outside Doors	
Condition of Weatherstripping	
Do Doors Leak Air?	

HVAC DATA FORM

Weather	
Outdoor Temperature	
Outdoor Relative Humidity	
Room Temperature	
Room Relative Humidity	

Is the heating or cooling system running? ____ Heating ____ Cooling ____ Both are off

Describe how heat is supplied to the room.

If there is cooling, describe how it is supplied to the room.

Heating/Cooling is controlled by: ____ Central Control/No Room Control

____ Programmable Thermostat ____ Adjustable Room Thermostat

____ Energy Management System Sensor

Hot Water Temperature:

Faucets Dripping?

Leaking Pipes?

Leaking/Running Toilets?

LIGHTING DATA FORM

Was the room/area occupied upon arrival?
Were the lights off or on?
Is natural light allowed into the room?
FLOURESCENT TUBE LIGHTING
What kind of ballasts? _________ **Electronic** _________ **Magnetic**
What kind of tubes? _________ **T 12** _________ **T 8** _________ **T 5**
OTHER LIGHTING
Are there LEDs, CFLs, or Incandescents in the room? If so, how many? Describe them.
LIGHTING CONTROLS
Can the lights be controlled by dimmer switches?
Are there occupancy sensors?
Can the lights be turned off and on individually or in banks?
EXIT SIGNS
What kind of lighting do the exit signs use? _________ **Incandescent** _________ **CFL** _________ **LED**

ELECTRICAL DEVICES DATA FORM

COMPUTER DATA:

How many computers are in the room?

How many computers were on?

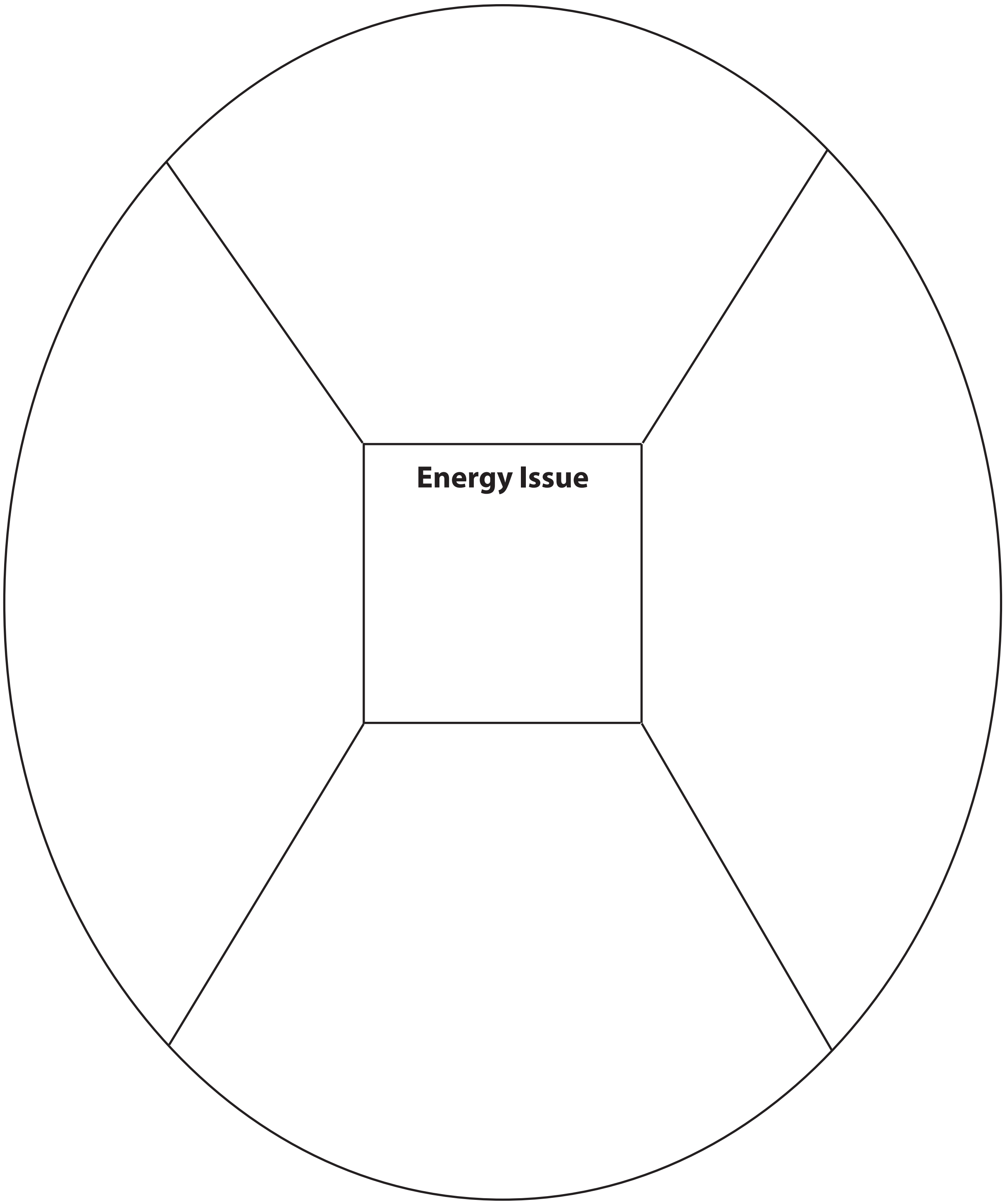
Were screen savers in use?

Were computers in stand-by mode?

ELECTRICAL DEVICES IN ROOM	ON?	VOLTAGE	CURRENT	WATTAGE

Brainstorming Solutions

During your energy survey, you observed conditions where energy was being used inefficiently. For each of these concerns, make a wheel organizer like the one below and brainstorm possible solutions. In the center of the wheel, write the name of the concern you are trying to address. In the outer sections, write the possible solutions.



Costs and Benefits

Make a chart like the one below for each energy issue so that you can analyze the possible solutions. When considering costs and benefits, keep in mind financial and time considerations, as well as the effort involved to make the solution a success.

You may need to do some research to establish costs and benefits. The building staff can help you determine these costs and benefits. In some cases, you may be able to quantify the costs and benefits as you did in the *Cost of Using Electrical Devices* worksheet. In other cases, you may need to describe the costs and benefits.

ISSUE/SOLUTION ORGANIZER

	SOLUTION 1:	**SOLUTION 2:**	**SOLUTION 3:**	**SOLUTION 4:**
ISSUE:				
Costs/Barriers				
Benefits				
Benefits Rating (+1, +2, or +3)				
Costs Rating (-1, -2, or -3)				
Score (Benefits-Costs)				
Conclusion				

Developing An Action Plan

Based on your analysis of the costs and benefits, determine what solutions make the most sense to pursue. For each solution, you will be determining the tasks that need to be accomplished in order to implement the solution.

If the plan includes asking those in the building to make changes in their behaviors, it will be important to include steps that motivate them to participate. Gaining their support and cooperation is a key step for a successful action plan. In addition, meeting the goals frequently depends on the awareness and commitment of the people who will be asked to change their behavior.

The energy-saving action plan will bring benefits to everyone. However, the school community must be made aware of these benefits for them to understand and willingly participate. Different people respond to different reasons for saving energy. People will probably not respond to simply being told to follow the plan and practice energy efficient behaviors. You need to provide them with reasons for saving.

The most effective reasons are:

- saving money,
- creating a more positive learning environment, and
- protecting or improving the environment.

It is important to include an on-going awareness effort as part of the plan so that everyone is reminded of the recommended actions and their benefits. There are many ways to broadcast an energy awareness message including TV station video messages, announcements or skits at meetings, pamphlets, posters, newsletters, stickers, e-mails, presentations, competitions, and more. Be mindful of environmental awareness as you design your campaign, using recycled materials and minimizing waste.

Communication is not a one-way process. Feedback from the school community is essential to any successful action plan. It lets you know how the program is performing and it also lets others know the effectiveness of their efforts. One way to obtain feedback is through an evaluation survey.

Action Plan Organizer

Assign team members to each task. Make a copy of the organizer on the next page for each issue.

For each concern, record:

- the actions that should be taken,
- the person or people who will be responsible for each action, and
- when the action should be completed.

Monitoring Results

Once you have taken action to save energy in your building, how will you know if your efforts are successful? Monitoring progress lets you know if your solutions were effective and can help you improve your plan.

Two of the most common ways of measuring your progress are:

- tracking energy consumption over time, and
- observing behaviors of building occupants.

You may come up with other ways that your program can be monitored. When monitoring behaviors, you need to determine the following:

- the actions to be monitored,
- when to monitor, and
- how often to monitor.

To track energy use over time you may need to obtain the data from your district business office. Your teacher can help you obtain this data. It might come in the form of utility bills, or it might be given to you as a table. Alternatively, you can read the utility meters for your building and keep track of the readings over time. The activities on pages 21-25 should have helped you learn how to read utility meters and utility bills. Your school may have digital meters instead of the dial meters shown. You can use the *Energy Monitoring Worksheet* on page 37 to monitor behaviors or design one of your own.

ACTION PLAN WORKSHEET

ENERGY ISSUE:

SOLUTION:

ACTION TO BE TAKEN	BY WHOM	DUE DATE
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		

COMMENTS:

ENERGY MONITORING WORKSHEET

TIME CODE
BS - Before School
MM - Mid Morning
LT - Lunch Time
AS - After School

For the month of ______________

MONITORING KEY
C- = Computers On, Room Unoccupied
C+ = Computers Off When Not In Use
D- = Door Open
D+ = Door Closed
L- = Light On, Room Unoccupied
L+ = Lights Off

ROOM	TIME	M	T	W	Th	F	M	T	W	Th	F	M	T	W	Th	F	M	T	W	Th	F	TOTAL (+ & -)
ROOM	TIME	M	T	W	Th	F	M	T	W	Th	F	M	T	W	Th	F	M	T	W	Th	F	TOTAL (+ & -)
ROOM	TIME	M	T	W	Th	F	M	T	W	Th	F	M	T	W	Th	F	M	T	W	Th	F	TOTAL (+ & -)

Glossary

aerator	a device that saves water by spreading the stream into many little drops
air conditioning	the control of the quality, quantity, temperature, and humidity of the air in an interior space
ampere	a unit of measure for an electric current; the amount of current that flows in a circuit at an electromotive force of one volt and at a resistance of one ohm; abbreviated as amp
appliance	a device for converting one form of energy or fuel into useful energy or work
ballast	a device used to control the voltage in a fluorescent lamp
baseload	the minimum amount of power that a utility or distribution company must have available to supply to its customers
boiler	a vessel or tank where heat produced from the combustion of fuels such as natural gas, fuel oil, or coal is used to generate hot water or steam for applications ranging from building space heating to electric power production or industrial process heat
British thermal unit (Btu)	the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit; equal to 252 calories
building envelope	the structural elements (walls, roof, floor, foundation, etc.) of a building that encloses conditioned space
Ccf	one hundred cubic feet, the standard measurement of natural gas volume, equal to one therm
compact fluorescent light	a smaller version of standard fluorescent lights that can directly replace standard incandescent lights; these lights consist of a gas filled tube, and a magnetic or electronic ballast
conduction	the transfer of heat through a material by the transfer of kinetic energy from particle to particle; the flow of heat between two materials of different temperatures that are in direct physical contact
convection	the transfer of heat by means of air currents
current (electric)	the flow of electrical energy (electricity) in a conductor, measured in amperes
daylighting	the use of direct, diffuse, or reflected sunlight to provide supplemental lighting for building interiors
dehumidifier	a device that cools air by removing moisture from it
depletion zone	a barrier region in a semiconductor that interferes with electron movement because it lacks excess electrons and spaces or holes for electrons (see semiconductor)
dimmer	a light control device that allows light levels to be manually adjusted; a dimmer can save energy by reducing the amount of power delivered to the light while consuming very little themselves
efficiency	under the First Law of Thermodynamics, efficiency is the ratio of energy output to energy input, and cannot exceed 100 percent. Efficiency under the Second Law of Thermodynamics is determined by the ratio of the theoretical minimum energy that is required to accomplish a task relative to the energy actually consumed to accomplish the task. Generally, the measured efficiency of a device, as defined by the First Law, will be higher than that defined by the Second Law
electrode	part of a semiconductor that collects, emits, or controls electric charge
emission	a substance or pollutant emitted as a result of a process
energy	the capability of doing work; different forms of energy can be converted to other forms, but the total amount of energy remains the same
energy audit	a survey that shows how much energy you use in your school, house, or apartment; used to help you find ways to use less energy
ENERGY STAR®	a government sponsored program that provides standards, ratings, and labeling for household products and appliances based on their energy efficiency

EnergyGuide labels	the labels placed on appliances to enable consumers to compare appliance energy efficiency and energy consumption under specified test conditions as required by the Federal Trade Commission
fluorescent light	the conversion of electric power to visible light by using an electric charge to excite gaseous atoms in a glass tube; the atoms emit ultraviolet radiation that is absorbed by a phosphor coating on the walls of the lamp tube, which produces visible light
foot-candle	a unit of illuminance; equal to one lumen per square foot
greenhouse gas	those gases, such as water vapor, carbon dioxide, tropospheric ozone, methane, and low level ozone that are transparent to solar radiation, but opaque to long wave radiation, and which contribute to the greenhouse effect
heating, ventilation, and air-conditioning (HVAC) system	all the components of the appliance used to condition interior air of a building
humidifier	a device that adds moisture to the air when too dry
humidity	a measure of the moisture content of air; may be expressed as absolute, mixing ratio, saturation deficit, relative, or specific
hygrometer	an instrument used to measure the moisture content, or humidity, of an environment
illuminance	a measure of the amount of light incident on a surface; measured in foot-candles or lux
incandescent	these lights use an electrically heated filament to produce light in a vacuum or inert gas-filled bulb
insulation	materials that prevent or slow down the movement of heat
kilowatt (kW)	a standard unit of electric power equal to one thousand watts, or to the energy consumption at a rate of 1,000 joules per second
killowatt-hour (kWh)	a unit or measure of electricity supply or consumption of 1,000 watts over the period of one hour; equivalent to 3,412 Btu
lamp	a light source composed of a metal base, a glass tube filled with an inert gas or a vapor, and base pins to attach to a fixture
light emitting diode (LED)	a semiconductor light source that emits light when electrons move within the semiconductor to higher and lower energy levels
load	the power required to run a defined circuit or system, such as a refrigerator, building, or an entire electricity distribution system; the amount of power drawn or used by a device to operate
lumen	a measure of the quantity of light based upon the spectral sensitivity of the photosensors in the human eye under high (daytime) light levels; photometrically it is the luminous flux emitted with a solid angle (one steradian) by a point source having a uniform luminous intensity of one candela
nameplate	a metal tag attached to a machine or appliance that contains information such as brand name, serial number, voltage, power ratings under specified conditions, and other manufacturer supplied data
occupancy sensor	an optical, ultrasonic, or infrared sensor that turns room lights on when it detects a person's presence and off after the space is vacated
phantom load	any appliance that consumes power even when it is turned off; examples include appliances with electronic clocks or timers, appliances with remote controls, and appliances with wall cubes (a small box that plugs into an AC outlet to power appliances)
photocell	a device in which photovoltaics are used to produce a current or voltage when exposed to radiant energy

power	energy that is capable or available for doing work; the time rate at which work is performed, measured in horsepower, watts, or Btu per hour; electric power is the product of electric current and electromotive force
power factor (PF)	the ratio of actual power being used in a circuit, expressed in watts or kilowatts, to the power that is apparently being drawn from a power source, expressed in volt-amperes or kilovolt-amperes
programmable thermostat	a type of thermostat that allows the user to program into the device's memory a pre-set schedule of times (when certain temperatures occur) to turn HVAC equipment on or off
R-value	a measure of the capacity of a material to resist heat transfer; the reciprocal of the conductivity of a material (U-value); the larger the R-value of a material, the greater its insulating properties
relative humidity	a measure of the percent of moisture actually in the air compared with what would be in it if it were fully saturated at that temperature; when the air is fully saturated, its relative humidity is 100 percent
return air	air that is returned to a heating or cooling appliance from a heated or cooled space
semiconductor	a material that has a conductivity level between an insulator and a conductor
therm	a unit of heat containing 102,300 British thermal units (Btu)
thermostat	a device used to control temperatures; used to control the operation of heating and cooling devices by turning the device on or off when a specified temperature is reached
U-value	the reciprocal of R-value; the lower the number, the greater the heat transfer resistance (insulating) characteristics of the material
vent	a component of a heating or ventilation appliance used to conduct fresh air into, or waste air or combustion gases out of, an appliance or interior space
ventilation	the process of moving air (changing) into and out of an interior space either by natural or mechanically induced (forced) means
volt	a unit of electrical force equal to that amount of electromotive force that will cause a steady current of one ampere to flow through a resistance of one ohm
watt	the rate of energy transfer equivalent to one ampere under an electrical pressure of one volt; one watt equals 1/746 horsepower, or one joule per second; the product of voltage and current (amperage)
watt meter	a device for measuring power consumption
weatherization	caulking and weather-stripping to reduce air infiltration and exfiltration into/out of a building

Games, Puzzles, and Activities

Looking for some fun energy activities? There are plenty of fun games, puzzles, and activities available at www.NEED.org/games.

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