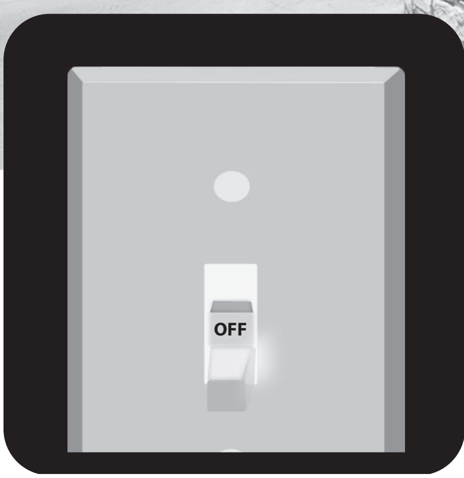
2016-2017

Learning and Conserving

Student Guide



National Energy Education Development Project

INTERMEDIATE AND SECONDARY

Energy Conservation and Efficiency Informational Text

The United States uses a lot of energy—over two million dollars worth of energy every minute, 24 hours a day, every day of the year. With only 4.44 percent of the world's population, we consume almost one-fifth (18.58 percent) of the world's energy resources.

The average American consumes 4.18 times the world average per capita consumption of energy. Every time we fill up our vehicles or open our utility bills, we are reminded of the economic impacts of energy use.

Energy Efficiency and Conservation

Energy is more than numbers on a utility bill; it is the foundation of everything we do. All of us use energy every day—for transportation, cooking, heating and cooling rooms, manufacturing, lighting, water heating, and entertainment. We rely on energy to make our lives comfortable, productive, and enjoyable. Sustaining this quality of life requires that we use our energy resources wisely. The careful management of resources includes reducing total energy use and using energy more efficiently.

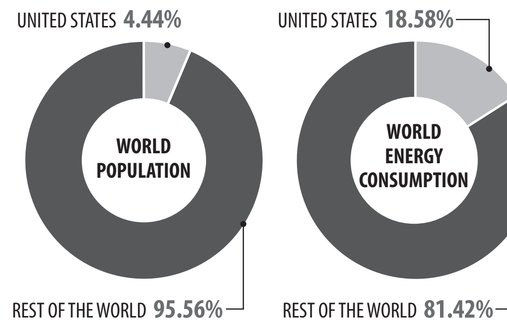
The choices we make about how we use energy—turning machines off when not in use or choosing to buy energy efficient **appliances**—will have increasing impacts on the quality of our environment and lives. There are many things we can do to use less energy and use it more wisely. These things involve energy conservation and energy efficiency. Many people use these terms interchangeably; however, they have different meanings.

Energy conservation includes any behavior that results in the use of less energy. **Energy efficiency** involves the use of technology that requires less energy to perform the same function. A compact fluorescent light bulb that uses less energy to produce the same amount of light as an incandescent light bulb is an example of an energy efficient technology. The decision to replace an incandescent light bulb with a compact fluorescent is an example of energy conservation.

Energy Sustainability

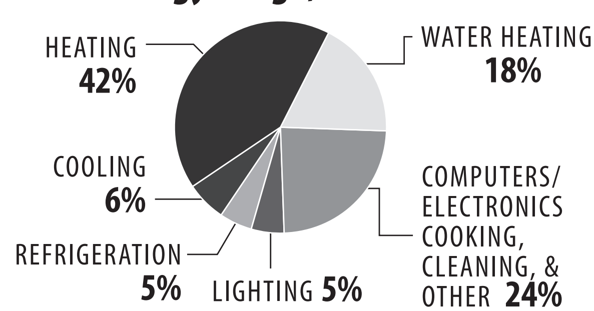
Efficiency and conservation are key components of **energy sustainability**—the concept that every generation should meet its energy needs without compromising the needs of future generations. Sustainability focuses on long-term actions that make sure there is enough energy to meet today's needs as well as tomorrow's. Sustainability also includes the development of new technologies for using fossil fuels, promoting the use of renewable energy sources, and encouraging policies that protect the environment.

Population Versus Energy Consumption, 2014



Data: Energy Information Administration

Home Energy Usage, 2014



Data: U.S. Department of Energy

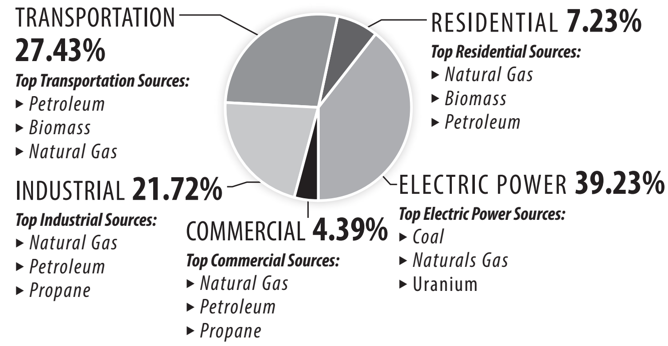
Sectors of the Economy

The U.S. Department of Energy uses categories to classify energy users—residential, commercial, industrial, transportation, and electric power generation. These categories are called the sectors of the economy.

Residences are people's homes. Commercial buildings include office buildings, hospitals, stores, restaurants, and schools. Residential and commercial energy use are lumped together because homes and businesses use energy in the same ways for heating, air conditioning, water heating, lighting, and operating appliances.

The graphic to the right shows that the electric power generation sector consumed the most primary energy in 2014. However, all of the other sectors, especially the residential, commercial, and industrial sectors, use electricity once it is generated; these sectors are the end users of the electric power. When combined together, and accounting for electricity use, the residential and commercial sectors of the economy consume more energy than any of the other sectors, with 39.754 total quads of energy. The residential portion of the sector consumed 21.558 quads of energy, with 14.440 quads of this energy coming from electricity. The commercial portion of the sector consumed 18.195 quads of energy (13.875 quads from electricity).

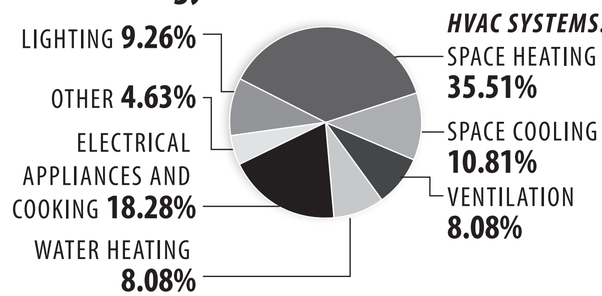
U.S. Energy Consumption by Sector, 2014



The residential, commercial, and industrial sectors use electricity. This graph depicts their energy source consumption outside of electricity.

Data: Energy Information Administration

School Energy Use



Data: Energy Information Administration

School Energy Consumption

A school building is an energy system made of many interrelated components. Some of these components are obvious, such as walls, roofs, lights, doors, and windows. 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 in which everyone is comfortable and healthy.

A school building's energy system includes these components:

- **Building Envelope:** This component includes everything that creates the boundaries between indoors and outdoors: walls, floors, roofs, windows, and doors.
- **Heating, Ventilation, and Air Conditioning (HVAC) Systems:** This component includes the equipment designed to provide heating, cooling, and fresh air. It also includes the devices that control the HVAC equipment, such as thermostats.
- **Lighting:** This component usually includes several types of fixtures that provide light for all of the activities in the school.
- **Electrical Appliances:** This component includes everything plugged into electrical outlets, such as refrigerators, copiers and computers, as well as appliances that are wired directly into the school's electrical system, such as ovens and refrigeration equipment in the cafeteria.

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.

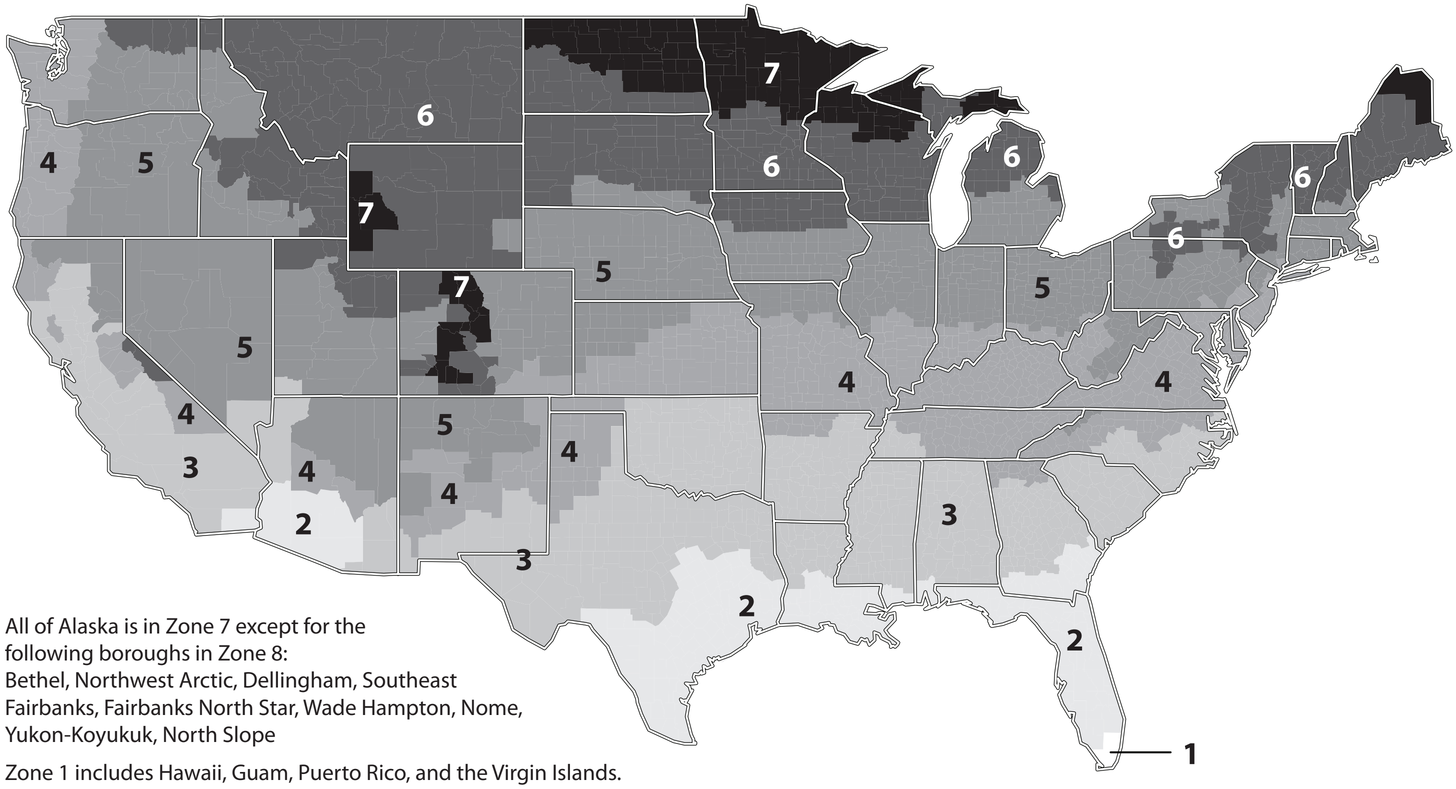
INSULATION

Image courtesy of Owens Corning

One way to reduce heat transfer is with **insulation**. Roof systems on most schools include insulation. There may also be insulation in the walls of the building, depending on how it is constructed. Insulation is rated using 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 reducing 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.

Even with insulation, air can still leak in or out through small cracks. Heat is carried along with the air through these cracks. Often the many small cracks in a building add up to a hole the size of a wide

Recommended R-Values for New Wood-Framed Homes



All of Alaska is in Zone 7 except for the following boroughs in Zone 8:
Bethel, Northwest Arctic, Dellingham, Southeast Fairbanks, Fairbanks North 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	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

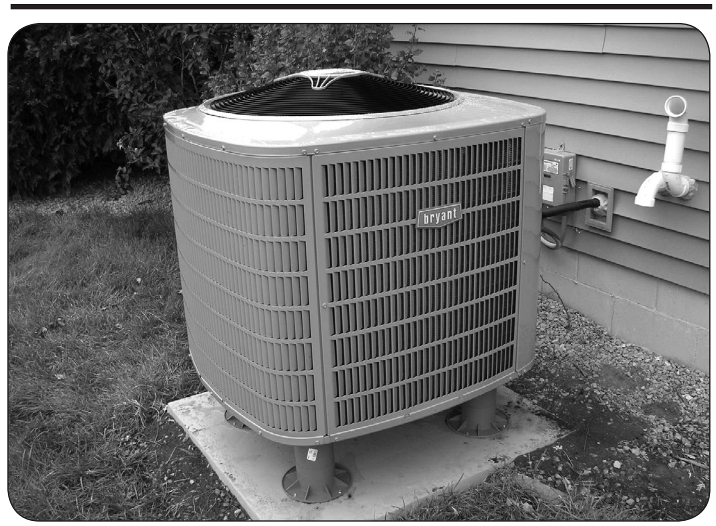
Data: U.S. Department of Energy

open door. Some of the cracks are obvious—those 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.

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

Doors should seal tightly and have door 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 double-paned, or constructed of two or more pieces of glass. Any cracks around the windows should be caulked and the windows checked often to make sure they seal tightly.

AIR CONDITIONING SYSTEM



When we seal a building by minimizing air transfer, we must keep in mind the need for fresh air for the occupants. To provide fresh air and exhaust stale air, school buildings have mechanical ventilation systems. In buildings with effective ventilation systems, even the windows can be sealed. With a good ventilation system, there should be no concerns with sealing all the air leaks in a school building.

Landscaping

Although the weather cannot 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 will 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 needed to keep a building comfortable.

Heating, Ventilation, and Air Conditioning (HVAC)

Heating and cooling systems, along with ventilation systems, use more energy than any other system in a school. Natural gas, heating oil, and sometimes electricity, are used to heat most buildings. Electricity is used to power cooling systems. Ventilation systems are necessary to provide fresh air and remove stale air and indoor air pollutants. About 54 percent of the average school district's energy bill is used to keep buildings at comfortable temperatures and provide fresh air for the buildings. The energy sources that power these heating and cooling systems (mostly fossil fuels) emit millions of tons of carbon dioxide into the atmosphere each year. They also generate sulfur dioxide and nitrogen oxides that cause acid rain.

Most school buildings are heated by boiler systems. These devices heat water to high temperatures, sometimes converting the water to steam, and then circulate it throughout the building via a system of pipes. Once the water in the pipes has transferred its thermal energy to the air in the building, it is circulated back to the boiler to be reheated.

Many classrooms are provided with heat, and some are provided 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, furniture, and other items.

Thermostats often control heating and cooling systems in the building. 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 when the temperature rises above the thermostat setting.

Many school districts control how high or low the temperatures 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 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, community meetings, or concerts.

For HVAC equipment to operate at optimum efficiency, it is necessary to maintain the equipment. Regular maintenance of equipment ensures that all systems and controls are functioning as they should. Every 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 come in—learning about energy and how to save it.

Temperature Management

The best heating system in the world cannot 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 (29°C) during the cooling season during the day. Windows and doors should be closed when the heating and cooling systems are operating.

Rooms and areas with windows in direct sunlight can be equipped with blinds that can help control temperature—closed in cooling months and opened in heating months—when sunlight is focused on them.

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

The **relative humidity**—the amount of moisture in the air—also affects comfort level and sometimes temperature. The more moisture, the warmer the air feels. The most comfortable relative humidity setting is between 40-60 percent. This range also minimizes the amount of bacteria, viruses, and molds in the air, and is healthy and comfortable for breathing. It can be difficult to manage and maintain humidity levels in large buildings like schools.

PROGRAMMABLE THERMOSTAT

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. Teaching occupants how to dress practically for the season can help them stay comfortable without using too much heat in the winter or air conditioning in the summer.

Indoor Air Quality (IAQ)

Over 58 million people, approximately 18 percent of the U.S. population, spend their days inside elementary and secondary schools. Students go to school to learn and, in order to make learning possible, the school building needs to be safe, healthy, and comfortable. One of the most important factors is making sure that the air in school buildings is healthy to breathe. A building with good indoor air quality has students, teachers, and staff who are healthy and alert. To ensure good indoor air quality, schools must eliminate air pollutants and introduce adequate clean, fresh air into the building. The amount of moisture in the building must be regulated as well.

Without efficient ventilation systems, indoor levels of air pollutants can be two to five times higher, and occasionally 100 times higher, than outdoor levels. IAQ problems can cause discomfort and contribute to short- and long-term health problems for students and staff.

Contributors to Poor Indoor Air Quality

Several factors in schools contribute to poor indoor air quality. Some of the most common factors include:

- Excess moisture and mold
- Dry-erase markers and pens
- Dust and chalk
- Cleaning materials
- Personal care products
- Odors and volatile organic compounds from exhaust, paint, caulk, and adhesives
- Insects and other pests
- Odors from trash
- Students and staff with communicable diseases
- Radon
- Classroom pets

All types of schools—new or old, big or small, elementary or secondary—can experience indoor air quality problems. Schools across the country have an array of indoor air problems. Biological problems, such as mold and mildew, are particularly pronounced in the Southeast and in places where humidity levels are high. Schools across the country, however, even in desert areas, have experienced mold problems.

Effects of Poor Indoor Air Quality

Poor indoor air quality can significantly impede a school from achieving its core mission—educating its students. Failure to prevent or quickly resolve air quality problems can:

- increase the potential for short-term and long-term health problems such as asthma, the number one cause of student absenteeism;
- increase the absentee rate of students, teachers, and staff;
- decrease the productivity and attitude of students, teachers, and staff; and/or
- strain relationships among school administrators, students, teachers, parents, and staff.

Classroom pets can contribute to poor indoor air quality.

Poor indoor air quality can increase the potential for short-term and long-term health problems such as asthma.

Ventilation

Since indoor air can be 2–5 times more polluted than outdoor air, most HVAC system designers understand that increased outdoor air supply is usually healthier. Yet, there are concerns over the implications that this added amount of outdoor air supply has on the energy used by the HVAC system, as well as humidity control. As a result, school designers often try to regulate the amount of outdoor air to equal the minimum requirement for school classrooms of 15 cubic feet per minute (cfm) of outside air per person. This standard has been established by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).

In some parts of the country, natural ventilation through operable windows can be an effective and energy efficient way to supplement HVAC systems to provide outside air ventilation, cooling, and thermal comfort when conditions permit (depending on temperature, humidity, outdoor air pollution levels, precipitation, etc.). Windows that open and close can enhance occupants' sense of well-being and feeling of control over their environment. They can also provide supplemental exhaust ventilation during renovation activities that may introduce pollutants into the space.

On the other hand, sealed buildings with appropriately designed and operated HVAC systems usually provide better indoor air quality than buildings with operable windows. Uncontrolled ventilation with outdoor air can allow outdoor air contaminants to bypass filters, potentially disrupt the balance of the mechanical ventilation equipment, and permit the introduction of excess moisture.

Regulating Moisture and Relative Humidity

Humidity is a measurement of the total amount of water vapor in the air. Relative humidity measures the amount of water vapor in the air relative to the amount of water vapor the air can hold, which depends on the temperature of the air. Humidity is measured with a tool called a **hygrometer**. Air acts like a sponge and absorbs water through the process of evaporation. Warm air is less dense and the molecules are further apart, which allows more moisture to be contained 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 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. 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 also 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.

Water Heating

Water heating is the second largest energy expense in residential buildings; it typically accounts for about 18 percent of energy consumed. Water heating is usually a much smaller percentage of school energy use, about eight percent, but it is significant. Schools often heat water with the 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, much like those used in residences. These are usually fueled by natural gas or electricity.

Heated water is used for hand washing, dishwashing, cleaning, and showers. There are five main ways to lower a school's water heating bill:

- 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.

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. Faucet aerators (which diffuse the flow of water from a faucet) can be installed in restrooms and classrooms. Aerators 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. Other ways to conserve hot water include taking shorter showers, fixing leaks in faucets and pipes, and using the lowest temperature water necessary. Some schools do not pipe hot water into classroom sinks for this reason.

Most water heater thermostats are set much higher than necessary. Lowering the temperature setting on a water heater saves energy. Installing energy efficient water heaters in school buildings can save hundreds of dollars a year.

Lighting

Lighting is a significant consumer of energy in a school system. An average school uses about 17 percent of the electricity (9% of the total energy) it consumes to light buildings and outside areas. Most 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 a small amount of mercury vapor. At the ends of the tubes are electrodes that emit electrons when heated by an electric current. When electrons strike the mercury vapor, the mercury 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**.

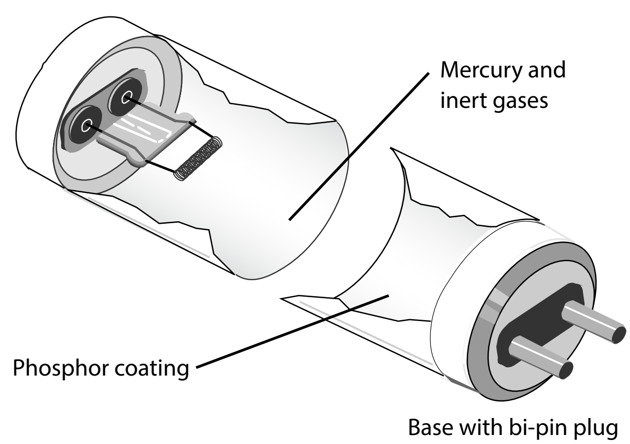
Fluorescent lights have ballasts that help move the electricity through the gas inside the bulb. Ballasts are electromagnets that produce a large voltage between the ends of the bulbs so the electricity will flow between them. There are two types of ballasts, magnetic and electronic. Magnetic ballasts produce a frequency of 60 Hertz (Hz), which means the light is flickering on and off 60 times a second. Electronic ballasts produce a frequency of at least 20,000 Hz. Fluorescent lights with electronic ballasts are more energy efficient than those with magnetic ballasts.

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.

Although fluorescent tubes in ceiling fixtures are always more energy efficient than incandescents, there are new, even more efficient lamps 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 lamps, although three-foot lamps are common as well. Older fixtures often contain T12 lamps that are 1½" in diameter and consume 34–40 watts. These lamps can be replaced with energy-saving T8 lamps that are 1" in

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.

diameter and typically consume 28–32 watts. Some newer systems are now using T5 lamps that are ⅝″ in diameter and are even more efficient than the T8 lamps.

Incandescent lighting is sometimes used in schools. Only 10 percent of the energy consumed by an incandescent bulb produces light; the rest is given off as heat. Legislation under the Energy Independence and Security Act of 2007 restricted how much energy light bulbs use. Today, most general use incandescent bulbs have been replaced on store shelves by more efficient lighting options including **halogen** incandescent bulbs, **compact fluorescent light bulbs** (CFLs), and **light emitting diode** bulbs (LEDs).

Halogen light bulbs are sometimes referred to as energy-saving, incandescent bulbs. They work much the same way as a traditional incandescent, but the filament is encapsulated and surrounded by halogen gas, allowing it to last longer and be more efficient. Fluorescent lights produce very little heat and are much more energy efficient than either type of incandescent bulb. CFLs use the same technology as overhead fluorescent lights, but they are designed to fit into lamps and other fixtures where incandescents are commonly used. All CFL bulbs have electronic ballasts.

Light emitting diode bulbs are even more efficient than CFL bulbs, last about 25 times longer than incandescent bulbs, and more than two and a half 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 next 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.

Lighting Controls

Lighting controls are devices that turn lights on and off or dim them. The simplest type is a standard snap switch. Other controls include photocells, timers, occupancy sensors, and dimmers. Snap switches, located in many 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.

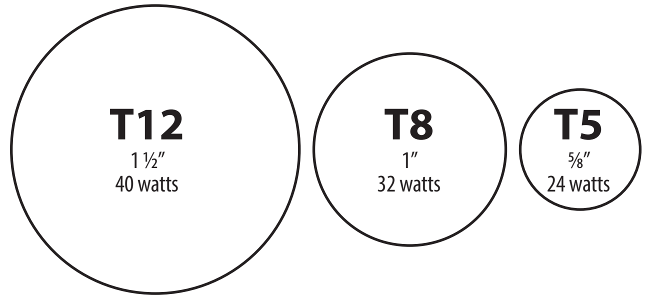
Mechanical or electronic time clocks automatically turn indoor or outdoor lights on and off for security, safety, and tasks such as janitorial work. An occupancy sensor activates lights when a person is in the area and then turn off the lights after the person has left.

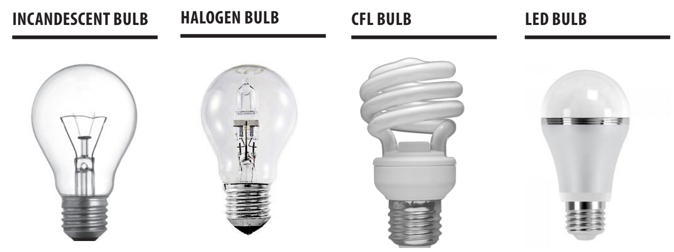
Dimmers reduce the wattage and output of incandescent and fluorescent lamps. Dimmers also significantly increase the service life of incandescent lamps; however, dimming incandescent lamps reduces their light output more than their wattage, making them less efficient as they are dimmed. Dimmers for fluorescents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

Even the best lighting system is not efficient if people do not use it wisely. In most schools, more light is used than needed and lights are often left on when no one is present. 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. Using sunlight is a good idea whenever possible. Studies have shown that students learn better in natural light than in artificial light.

Fluorescent Lighting Efficiency

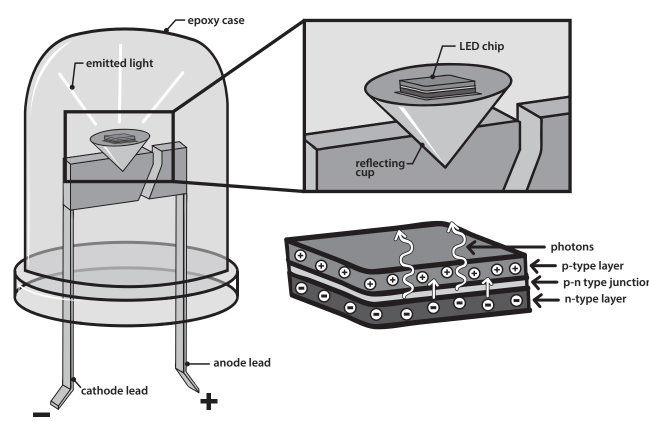
A T12 bulb consumes up to 40 watts of energy to produce a given amount of light. T8 and T5 bulbs use less energy to produce the same amount of light.





LEDs offer better light quality than incandescent bulbs and halogens, last 25 times as long, and use even less energy than CFLs. LEDs now have a wide array of uses because technology has improved and costs have decreased. It is possible to see CFL use decrease as LED costs continue to improve.

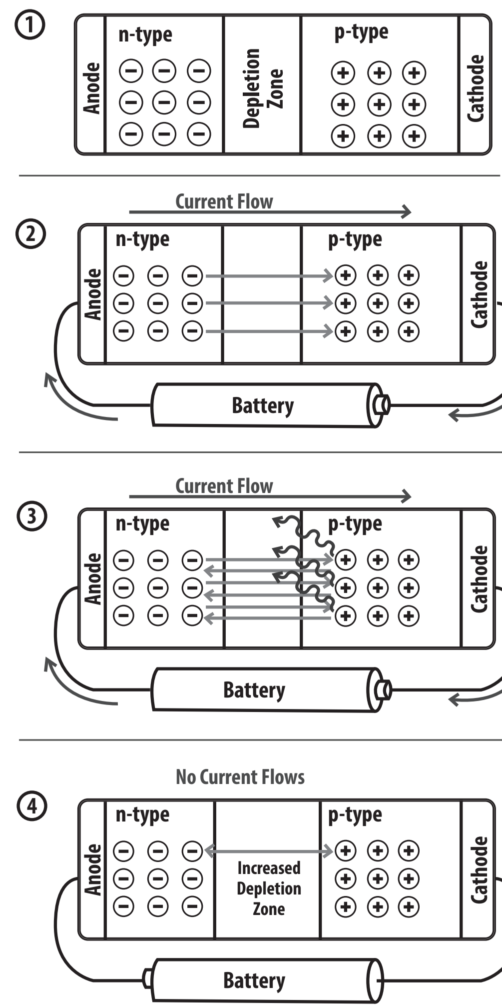
Inside an LED



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.

How Light Emitting Diodes Work



Electrical Appliances

A school building contains many electrical devices, called **plug loads**, that contribute to the learning process and help occupants stay comfortable and safe. It is estimated that about 30 percent of the total electricity consumed by a school is used to power these electrical devices. Managing the use of such equipment can greatly reduce a school's electricity consumption.

Look around any classroom and you will see many appliances. A quick survey of the typical classroom and school building reveals many kinds of electrical appliances, such as:

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

Many of these devices are important to the learning environment. In addition, there are appliances that teachers and school staff bring from home that are not related to teaching, but are routine devices found in any office. Many electrical appliances, 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 a long warm–up time. 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.

Once students, teachers, and staff are educated about the impacts of energy consumption, they are often willing to reduce their use of these devices. By simply monitoring daily use of plug loads, students and staff can lower the school's utility bills, saving the school system money.

Many computers, TVs, DVD players, and other electrical devices use electricity even when they are turned off. This type of electricity consumption is known as **phantom load**, because it can easily go unnoticed. Phantom loads are also known as standby power or leaking electricity. Phantom loads exist in many electronic or electrical devices found in schools. Equipment with electronic

Roy Lee Walker Elementary School, McKinney, TX, incorporates a number of energy efficient and renewable design features to help lower energy bills, including daylighting, rainwater collection, solar water heating, wind energy, and high efficiency lighting.

Image courtesy of NREL

clocks, timers, or remote controls, portable equipment, and office equipment with wall cubes (small box-shaped plugs that plug into AC outlets to power appliances) all have phantom loads and can consume up to 40 watts when turned off, depending on the device. These appliances should be plugged into surge protectors so that all of the power can be turned off when they are not in use, or at the end of the day.

Federal Government Guidelines for Appliances

When shopping for a new appliance or lighting, 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 and devices can be found on the ENERGY STAR® website at www.energystar.gov.

energy

CHANGE FOR THE BETTER WITH ENERGY STAR

Another way to determine the efficiency of appliances 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.

The School Building as a System

When managing the systems of a school to minimize energy consumption, it's important to maintain the health and comfort of the occupants. After all, the reason energy is being used in the first place is to provide a good learning environment. Human beings have specific 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. Energy can be saved by turning off lights and lowering the heat in winter, but doing so thoughtlessly 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. The school is not only a system in itself, but also a part of a global energy system that has finite energy resources.

Energy Definitions and Conversions

Definitions

Btu: British thermal unit; a measure of thermal energy (heat); the amount of heat needed to raise the temperature of one pound of water by one degree Fahrenheit; one Btu is approximately the amount of energy released by the burning of one wooden kitchen match

Ccf: one hundred cubic feet; a unit used to measure natural gas usage

Current: the flow of electrons; the number of electrons flowing past a fixed point; measured in amperes — A

Energy: the ability to do work; work involves a change in movement, temperature, energy level, or electrical charge

Electricity: the energy of moving electrons; measured in kilowatt-hours — kWh

Force: a push or pull that gives energy to an object, causing it to start moving, stop moving, or change direction

kWh: kilowatt-hour; one kilowatt of electricity expended over one hour; one kilowatt-hour of electricity is the amount of energy it takes to burn a 100-watt light bulb for 10 hours. In 2014, the average cost of one kilowatt-hour of electricity for residential customers in the U.S. was about $0.125; the average cost for commercial customers, such as schools, was about $0.10

Mcf: one thousand cubic feet; a unit used to measure natural gas usage

MMBtu: 1,000,000 British thermal units (Btu)

Therm: a measure of thermal energy; one therm equals 100,000 Btu

Voltage: electric push or pressure; the energy available to move electrons; measured in volts —V

Watt: the measure of electric power; the number of electrons moving past a fixed point in one second multiplied by the pressure or push of the electrons; W = A x V

Natural Gas Conversions and Cost, 2014

In 2014, the average heat content of natural gas for the residential, commercial, and industrial sectors was about 1,030 Btu per cubic foot.

1 cf = 1,030 Btu

1 Ccf = 103,000 Btu or 1.030 therms

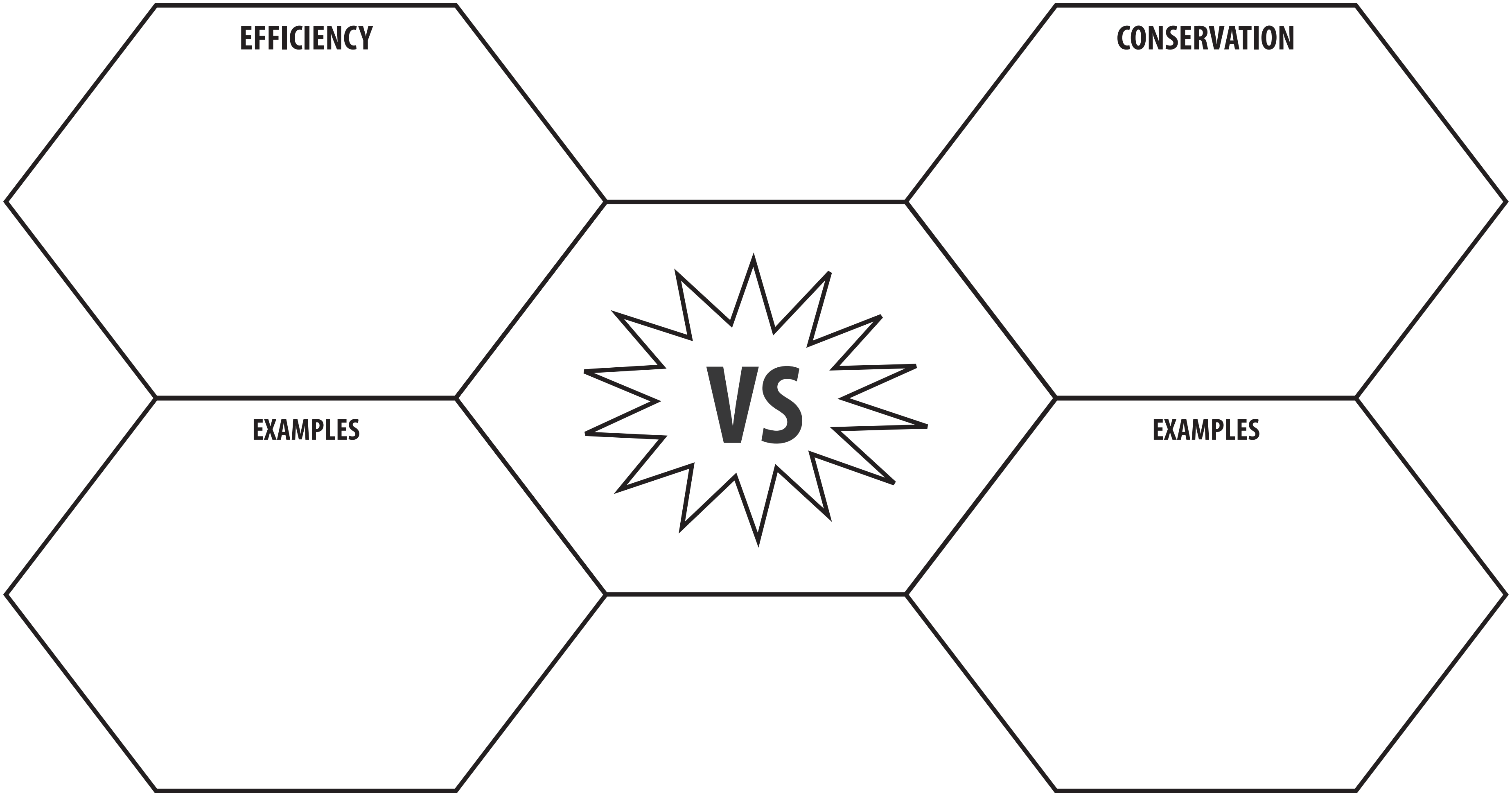
1 Mcf = 1.030 MMBtu or 10.30 therms

1 kWh = 3,412 Btu

1 therm = 100,000 Btu

The cost of natural gas varies widely by sector of the economy. In 2014, one Mcf of natural gas cost $5.19 in the electric generating sector, $5.55 in the industrial sector, $8.90 in the commercial sector, and $10.97 in the residential sector.

Efficiency vs. Conservation



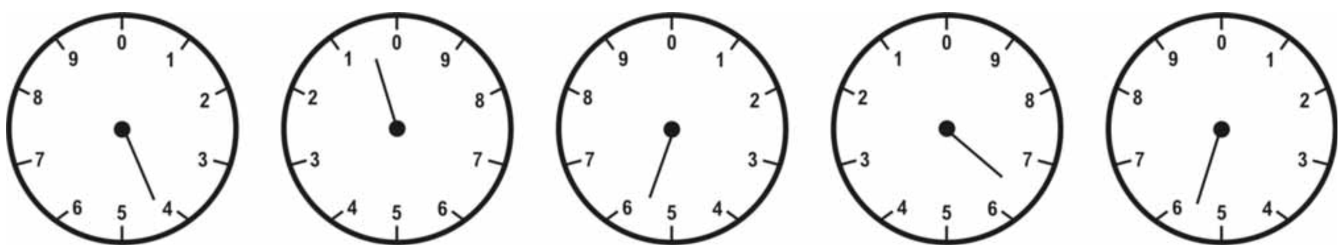
Explain how energy efficiency and conservation work together.

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. Sometimes meters are digital, and sometimes they have dials. If the meter has dials, the face of the meter will have 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 at school:



4 0 5 6 5

The total reading is 40,565

On Friday afternoon, this was the electric meter reading at school:

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?

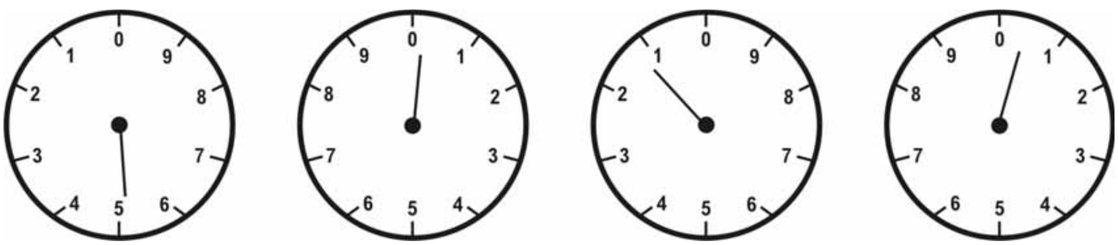
_____________ **kWh X $0.10/kWh = $** ______________________

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. Here are two examples with the correct numbers below the dials:

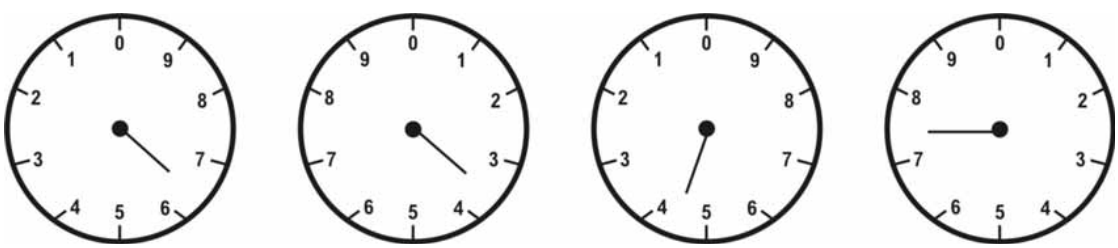
On December 1, this was the natural gas meter reading at school:



5 0 1 0

The total reading is 5,010

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



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 = Natural gas used

6,347 – 5,010 = 1,337 Ccf

Natural gas is measured in 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?

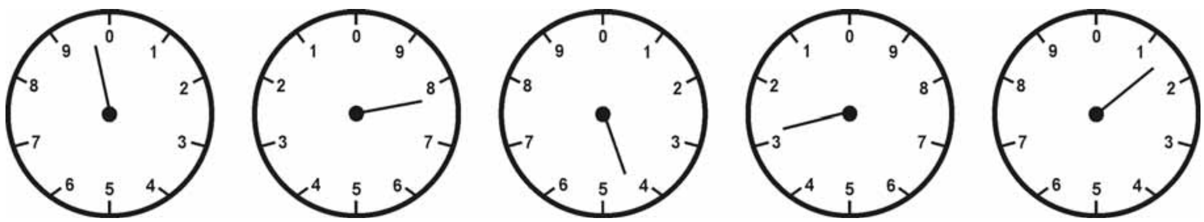
Usage Charge = ______________ Ccf X $0.89/Ccf = $ __________________

Reading Meters Worksheet

Electric Meter

On January 1, this was the electric meter reading at school:

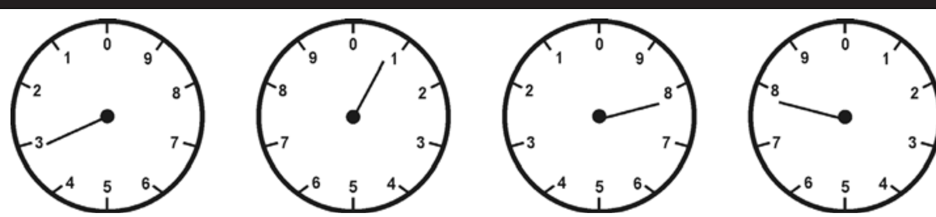
On February 1, this was the electric meter reading at school:



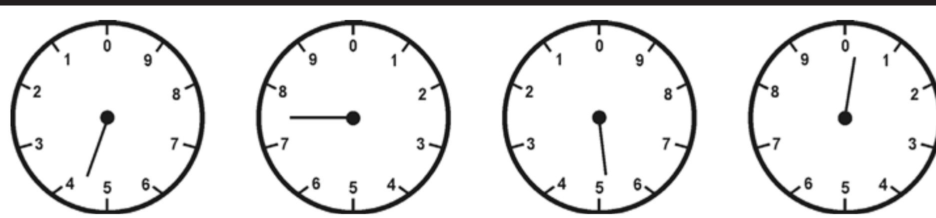
1. How many kilowatt-hours of electricity were used during January?
2. If the cost of electricity is $0.10 per kWh, how much did the electricity cost for January?
3. What was the average cost of electricity per day during January?

Natural Gas Meter

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



On February 1, this was the natural gas meter reading at school:



1. How many Ccf of natural gas were used during January?
2. If the cost of natural gas is $0.89 per Ccf, what was the cost of natural gas during January?
3. What was the average cost of natural gas per week during January?

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

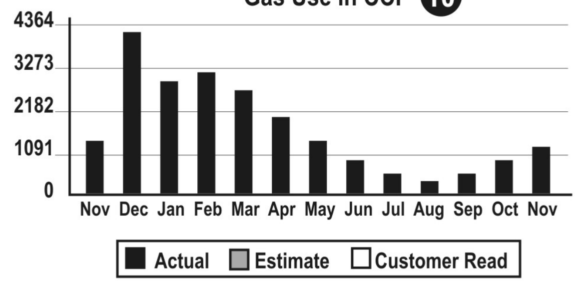
Delivery	6 282.14
Gas Supply	7 1,377.91
Total Current Charges	**$1,660.05**
Total Account Balance	8 **$1,660.05**

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

Monthly Usage Comparison

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

0116600500000000000000936868686868600012345678

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. This is 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

Facts of Light

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?



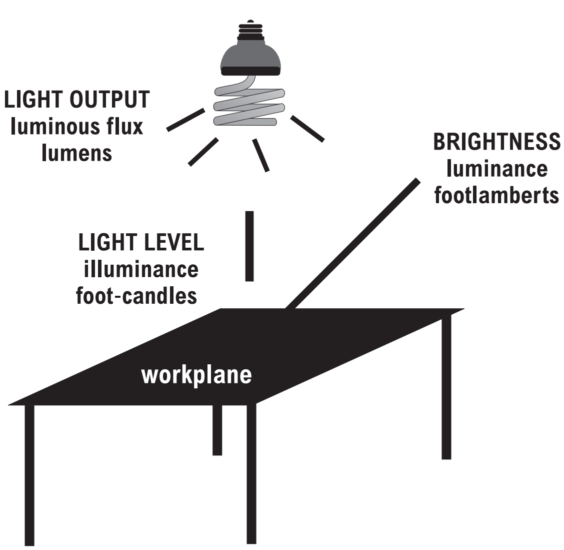

All bulbs provide about 850 lumens of light.

	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**				

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. On the back of the meter, pull out the meter's tilt stand and 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 work plane on which the light meter is placed. Foot-candles are work plane lumens per square foot. The light meter can measure the quantity of light from 0 to 1000 fc.

Brightness or Luminance

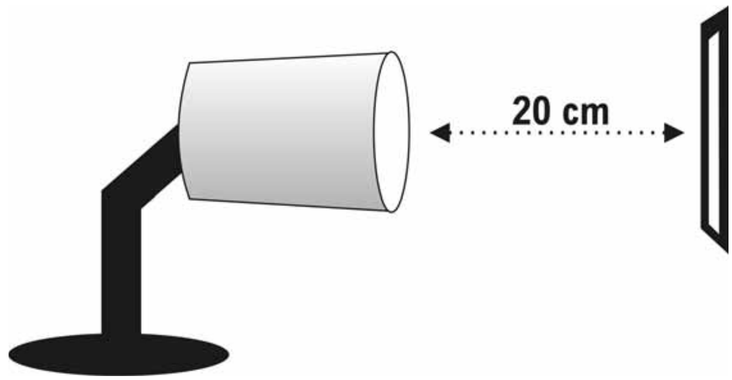
Another measure of light is its brightness or luminance. Brightness is a measure of the light that is reflected from a surface in a particular direction. Brightness is measured in footlamberts (fL).

Recommended Light Levels

Below is a list of recommended illumination levels for school locations in foot-candles. These illumination levels align with the recommendations from the Illumination Engineering Society of North America.

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**

Light Bulb Investigation 1



Objective

Students will be able to compare the heat output of incandescent, compact flourescent, and light emitting diode bulbs.

Materials

- 3 Lamps
- 1 Incandescent light bulb
- 1 Compact fluorescent light bulb (CFL)
- 1 Light emitting diode bulb (LED)
- 3 Thermometers
- Tape

Question

How does the heat output differ between an incandescent, compact flourescent, and light emitting diode bulb?

Hypothesis

Procedure

1. Place the incandescent bulb in one lamp the CFL in another lamp, and the LED bulb in the third lamp. (If you do not have three lamps, conduct three trials, one for each bulb.)
2. Place the lamps on a table about 20 cm away from a blank wall. The light should face the wall.
3. Tape the thermometers to the wall so the lamps shine directly on them, as shown in the diagram above.
4. Record the thermometer readings in the chart below.
5. Turn on the lamps. Record the thermometer readings at 2-minute intervals for 10 minutes.
6. Calculate and record the change in temperature (ΔT) for each bulb. Compare.

Data

BULBS	TEMPERATURE (CELSIUS)						
	0 MIN	2 MIN	4 MIN	6 MIN	8 MIN	10 MIN	ΔT
Incandescent							
CFL							
LED							

Conclusion

What did you learn about the heat output of the three bulbs? Use data to support your answer.

Light Bulb Investigation 2

✪ Objective

Students will be able to compare the wattage of incandescent, compact flourescent, and light emitting diode bulbs.

Materials

- 3 Lamps
- 1 Incandescent light bulb
- 1 Compact fluorescent light bulb (CFL)
- 1 Light emitting diode bulb (LED)
- 1 Kill A Watt™ monitor

Question

How does the wattage vary for different types of bulbs?

Hypothesis

✔ Procedure

1. Place the incandescent bulb in one lamp the CFL in another lamp, and the LED bulb in the third lamp. (If you do not have three lamps, conduct three trials, one for each bulb.)
2. Place the lamps on a table.
3. Plug the Kill A Watt™ monitor into an outlet and plug the lamp with the incandescent bulb into the monitor.
4. Turn on the lamp. Record the wattage using the Kill A Watt™ monitor. Turn off the lamp and unplug it from the monitor.
5. Plug the lamp with the compact fluorescent bulb into the monitor. Turn on the lamp and record the wattage. Turn off the lamp.
6. Plug the lamp with the LED bulb into the monitor. Turn the lamp on and record the wattage. Turn off the lamp.
7. Compare the wattage measured by the monitor to the stated wattage of the bulbs found on their packaging, or printed on the bulbs themselves.

Data

BULBS	WATTAGE FROM MONITOR	STATED WATTAGE
Incandescent		
CFL		
LED		

Conclusion

What did you learn about the wattage used by the three bulbs? Use data to support your answer.

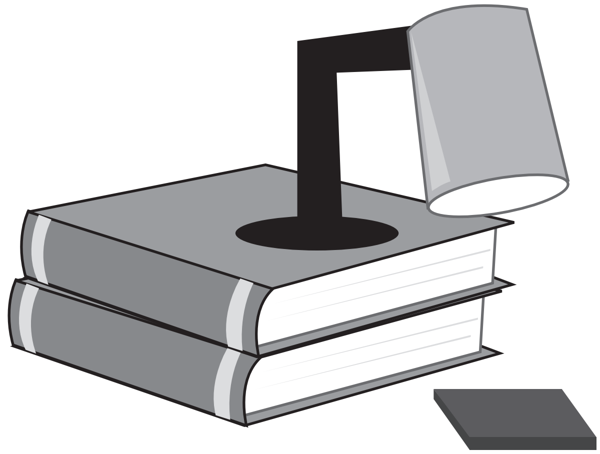
Light Bulb Investigation 3

Objective

Students will be able to compare the light output of incandescent, compact flourescent, and light emitting diode bulbs.

Materials

- 3 Lamps
- 1 Incandescent light bulb
- 1 Compact fluorescent light bulb (CFL)
- 1 Light emitting diode bulb (LED)
- 1 Light meter
- Books, all the same thickness



Question

How does the light output vary in different types of light bulbs?

Hypothesis

Procedure

1. Place the incandescent bulb in one lamp the CFL in another lamp, and the LED bulb in the third lamp. (If you do not have three lamps, conduct three trials, one for each bulb.)
2. Place the lamps on a table on identical stacks of books, as shown in the diagram above.
3. Plug the lamps into an outlet and turn them on.
4. Use the light meter to measure the light output of the lamps.
5. Record your measurements and calculations in the data table.
6. Compare the output measured by the light meter to the stated output of the bulbs found on their packaging, or printed on the bulbs themselves.

Data

BULBS	FOOT-CANDLES FROM LIGHT METER	STATED LUMEN OUTPUT
Incandescent		
CFL		
LED		

Conclusion

What did you learn about the light output of the three bulbs? Use data to support your answer.

Light Level Investigation

Objective

Students will be able to determine light levels in different areas using a light meter.

Materials

- 1 Light meter

Question

Does your school/building use the proper amount of lighting in all spaces?

Hypothesis

Procedure

1. Use the light meter to measure the light levels in your classroom with the lights on and off. If you can adjust the amount of light further, measure the light levels for all settings. Record the measurements in the chart below with descriptions of the light settings.
2. Use the light meter to measure the light levels in the hallway outside your classroom, and outside at different times of the day. Record the measurements in the chart below with descriptions of the areas and times of day.
3. As you are working on different tasks in the classroom, compare the light level in the room with the recommended light levels on page 22.

Data

DESCRIPTION OF AREA AND CONDITIONS	TIME	LIGHT LEVEL

Conclusion

Are the light levels around your school appropriate for the area? Why or why not?

Flicker Checker Investigation

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 ultraviolet (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, or 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.

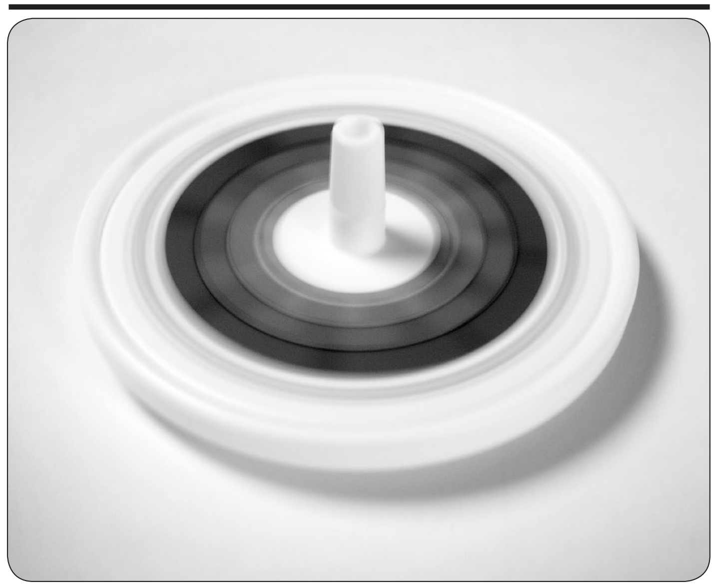
The reason that the Flicker Checker can tell the difference between the magnetic and electronic ballasts is because of the way the current is delivered to the gas. In any outlet in the United States that is powered by an electric company, the electricity is sent as alternating current—it turns on and 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.

✔ Procedure

To determine which type of ballast a fluorescent light contains, spin the Flicker Checker under it. If you see smooth circles, as shown in the picture to the right, the fluorescent light contains an electronic ballast. If you see a checkered pattern that moves from ring to ring, the light contains a magnetic ballast.

AREA	TYPE OF BALLAST
Classroom	
Cafeteria	
Gym	
Hallway	
Office	
Restroom	

FLICKER CHECKER SHOWING AN ELECTRONIC BALLAST



Electric Nameplates Investigation

Some appliances use more energy than others to accomplish the same task. Appliances that are very energy efficient are approved by the government's ENERGY STAR® program and have the ENERGY STAR® label on them. This means they have met high standards set by the government for energy efficiency.

Every machine that runs on electricity has an electric nameplate on it. The nameplate is usually a silver sticker that looks like the picture below. The nameplate has information about the amount of electricity the machine uses. Sometimes, the current is listed. The current is measured in amperes (A). Sometimes, the voltage the machine 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.

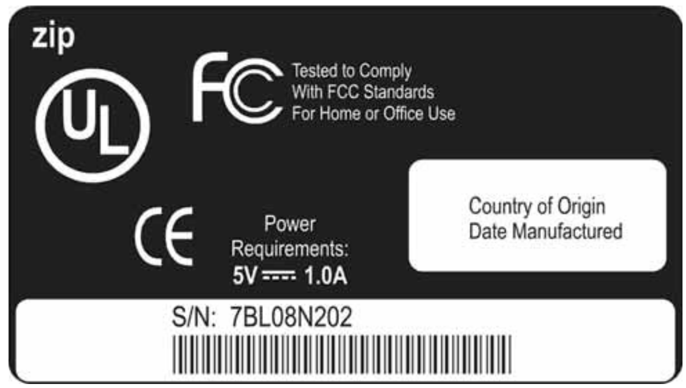
If the wattage is not listed, you can calculate the wattage using the following formula:

wattage = current x voltage

W = A x V

W = 1.0A x 5V

W = 5W



Often, the letters UL are on the nameplate. UL stands for Underwriters Laboratories, Inc., which conducts tests on thousands of machines and appliances. The UL mark means that samples of the machines and appliances have been tested to make sure they are safe.

You can find out how much it costs to operate any appliance or machine if you know the wattage. Let's take a look at some of the machines in your school. The nameplate is usually located on the bottom or back. See if you can find the nameplates on the computers, printers, monitors, televisions, and other machines in your classroom. Put the information in the chart below and figure out the wattage for each one.

MACHINE OR APPLIANCE	CURRENT	VOLTAGE	WATTAGE	UL TESTED
Copier	*11A*	*115V*	*1,265W*	*yes*

The Cost of Using Electrical Devices Investigation

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 schools in the U.S. is about ten cents 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 over 40 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 30.11 percent comes from burning natural gas, petroleum, and biomass.

The general rule is that, 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 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 x rate of CO_2/kWh

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

MACHINE OR APPLIANCE	KILOWATTS (kW)	RATE OF CO_2/kWh (LBS)	HOURS PER YEAR	CO_2/YEAR (LBS)
Copier	*1.265 kW*	*1.23*	*400 hours*	*622.38*

EnergyGuide Labels

The Federal Government requires that appliance manufacturers provide information about the energy efficiency of their products to consumers so that they can compare the life cycle cost of the appliances, as well as the purchase price. The life cycle cost of an appliance is the purchase price plus the operating cost over the projected life of the appliance.

The law requires that manufacturers place EnergyGuide labels on all new refrigerators, freezers, water heaters, dishwashers, clothes washers, room air conditioners, central air conditioners, heat pumps, furnaces, televisions, and boilers. The EnergyGuide labels list the manufacturer, the model, the capacity, the features, the amount of energy the appliance will use a year on average, its comparison with similar models, and the estimated yearly energy cost.

For refrigerators, freezers, water heaters, dishwashers, televisions, and clothes washers, the labels compare energy consumption in kWh/year or therms/year. For room air conditioners, central air conditioners, heat pumps, furnaces, and boilers, the rating is not in terms of energy consumption, but in energy efficiency ratings, as follows:

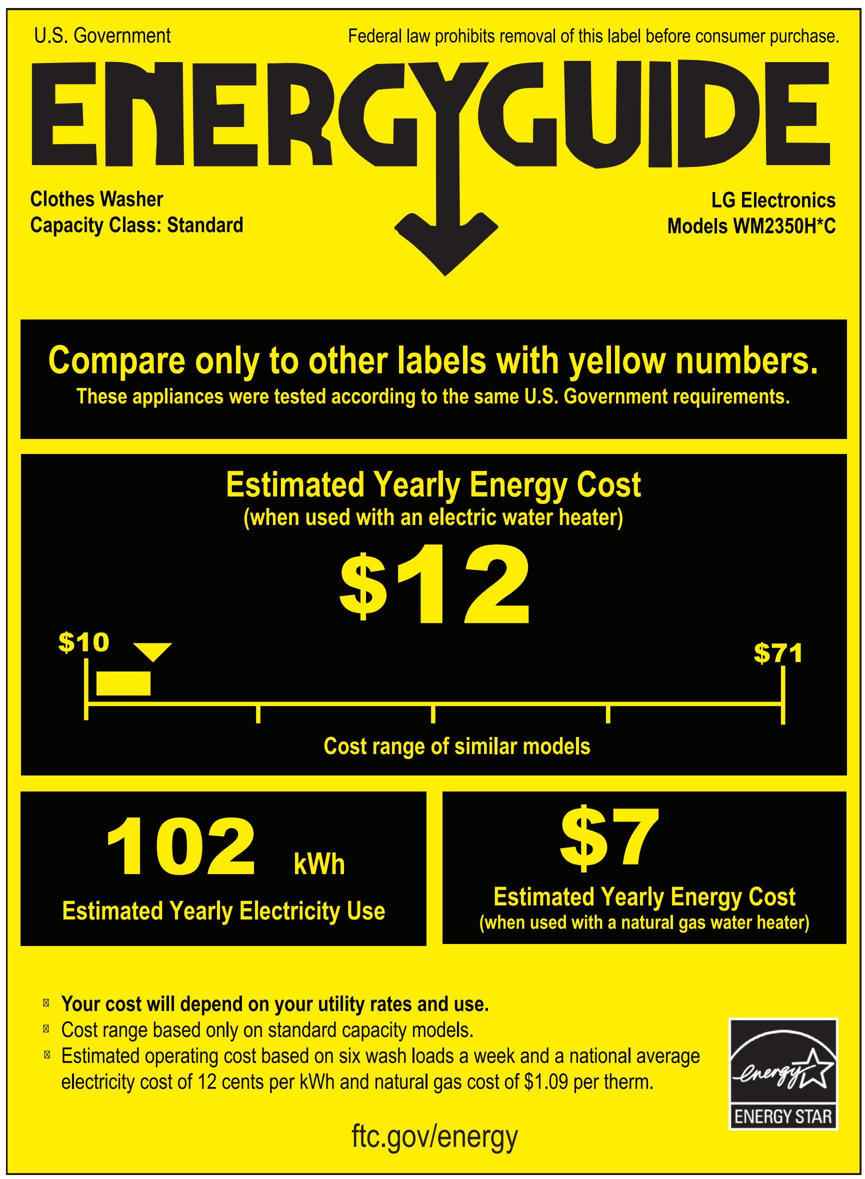
EER: **Energy Efficiency Rating**
(room air conditioners)

SEER: **Seasonal Energy Efficiency Rating**
(central air conditioners)

HSPF: **Heating Season Performance Factor**
(with SEER heat pumps)

AFUE: **Annual Fuel Utilization Efficiency**
(furnaces and boilers)

Clothes washer: To the right is an EnergyGuide label from an average energy-using clothes washer. Notice that it costs more to run the washer with an electric water heater than a natural gas water heater.



Comparing Appliances

Your family needs to buy a new washing machine. Washing machines usually last a long time—10 years or more—so you can save a lot of money on an energy efficient one. Use the chart below to figure out which washing machine to buy, comparing the information on the EnergyGuide labels.

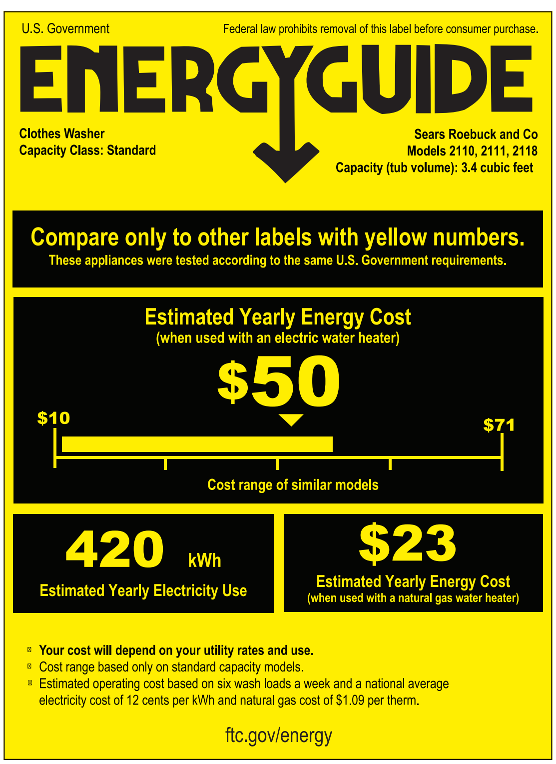
- **How many years will it take before you begin to save money?**
- **How much money will you have saved after ten years?**
- **Extension: Research the cost of electricity and natural gas in your area. Recalculate the operating cost of each machine based on your local rates.**

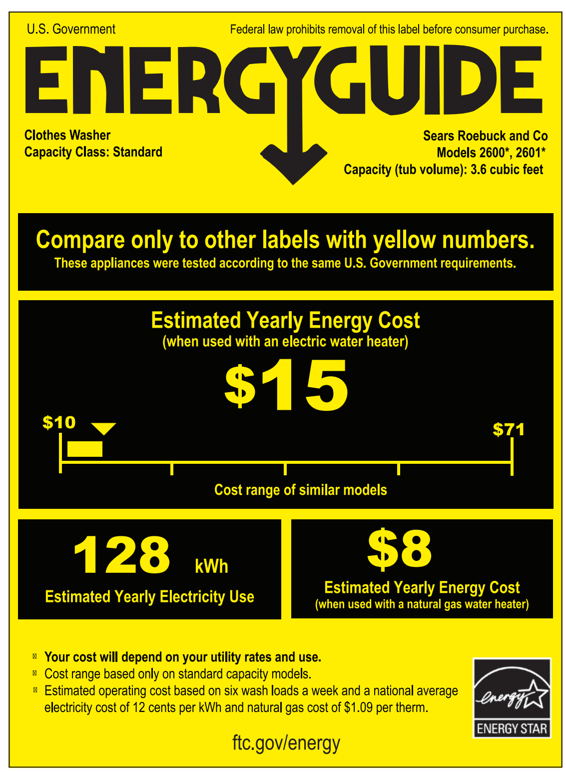
Washing Machine 1: Purchase Price: $410.00

WASHING MACHINE 1	EXPENSES	COST TO DATE
Purchase Price		
Year One		
Year Two		
Year Three		
Year Four		
Year Five		
Year Six		
Year Seven		
Year Eight		
Year Nine		
Year Ten		

Washing Machine 2: Purchase Price: $530.00

WASHING MACHINE 2	EXPENSES	COST TO DATE
Purchase Price		
Year One		
Year Two		
Year Three		
Year Four		
Year Five		
Year Six		
Year Seven		
Year Eight		
Year Nine		
Year Ten		





Note: These EnergyGuide labels were found on 2013 model year appliances. The estimated yearly operating costs on the labels are based on 2012 electricity and natural gas rates.

Kill A Watt™ Monitor

The Kill A Watt^{TM} 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 one 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 meter 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?

The formula **Volts x Amps = Watts** is used to find the energy consumption of an electrical 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 an AC device, the following formula is used:

Volts x Amps x PF = Watts Consumed

Kill A Watt™ Investigation 1

Utility companies measure power consumption in kilowatt-hours (kWh). One 100-watt incandescent light bulb consumes 1 kWh of electricity in ten hours. If the bulb is turned on an average of 80 hours a month, it consumes 8.0 kWh/month. To determine annual cost, multiply the kWh per month by the number of months used per year by the cost per kWh:

kWh/month x month/year x cost/kWh = annual cost

The average cost of a kWh of electricity for residential consumers is $0.125 (8 kWh/month x 12 months/year x $0.125/kWh = $12.00/year). The average cost of a kWh of electricity for commercial consumers such as schools is $0.10 (8 kWh/month x 9 months/year x $0.10/kWh = $7.20/year).

✪ Objective

Students will determine how much power selected electrical devices use per year.

✔ Procedure

1. Select several different electrical devices in the school and estimate the number of hours they are in use per week. Record your estimates in the table below.
2. Multiply the number of hours each device is used per week by the number of weeks it is used per year. For example, an item used year-round would require multiplying by 52, or the number of weeks in a year. Items only used during the school year or during specific seasons may be used less and would require multiplying by a different factor. A school year is typically around 40 weeks. Multiply and record this number in the table.
3. Use the Kill A Watt™ monitor to measure the watts used by each device and record it in the table.
4. Divide the number of watts used by 1,000 to convert watts into kilowatts.
5. Multiply the hours used per year by the number of kilowatts used. Multiply this number by the cost of a kWh to determine the annual cost of operating the device. Record your answer in the table.

Data

Record your measurements and calculations in the table below.

ELECTRICAL DEVICE	HOURS PER WEEK	HOURS PER YEAR	WATTS MEASURED (W)	KILOWATTS (kW)	RATE ($/kWh)	ANNUAL COST
Laptop	*15*	*600*	*20*	*.02*	*$0.10*	*$1.20*

⁂ Conclusion

- Which electrical device consumes the most power?
- Which electrical device consumes the least power?
- Which electrical device costs the most to operate?
- Which electrical device costs the least to operate?

Kill A Watt™ Investigation 2

Some electrical devices appear to use more power when they are in active mode than when they are in idle mode. These devices include pencil sharpeners, copiers and printers, clock radios, and others. In addition, some devices such as fans appear to use more power at high speeds than at low speeds.

The Kill A Watt™ monitor can be used to measure the power consumption of these electrical devices to determine the difference in consumption when these devices are operating in different modes.

✪ Objective

Students will determine if electrical devices use different amounts of power when they are in different modes or operated at different speeds.

✔ Procedure

1. Select several electrical devices that might consume power at different rates while active and idle or while operating at different speeds. Estimate the average number of hours per week each device is in active use and the average number of hours per week the device is turned on, but idle, by interviewing users. Estimate the values with devices that can operate at different speeds. Record your estimates in the table below.
2. Multiply these values by the number of weeks it is in use per year. Multiply by 52 (total weeks in a year) or 40 (40-week school year) to calculate the average yearly amount of time each device is in use in each mode. Record these values in the table below.
3. Use the Kill A Watt™ monitor to measure the watts used in different modes of operation and record in the table below.
4. Divide the number of watts used by 1,000 to convert watts into kilowatts.
5. Multiply the hours used per year by the number of kilowatts used. Multiply this number by the cost of a kWh to determine the annual cost of operating the device in each mode. Record your answer in the table.

Data

Record your measurements and calculations in the table below.

ELECTRICAL DEVICE	HOURS PER WEEK	HOURS PER YEAR	WATTS MEASURED (W)	KILOWATTS (kW)	RATE ($/kWh)	ANNUAL COST
Copier (idle)	*36*	*1440*	*20*	*.02*	*$0.10*	*$2.88*
Copier (active)	*4*	*160*	*1200*	*1.2*	*$0.10*	*$19.20*

Conclusion

- Do some devices use more power when they are active than when they are idle?
- Do some devices use more power on high speed than on low speed?

Note: Because some electrical devices cycle on and off without our control, the most accurate way to determine actual power consumption is to use the Kill A Watt™ monitor to measure consumption over a 12–24 hour period. Refrigerators, for instance, cycle on and off in response to internal temperature sensors.

Kill A Watt™ Investigation 3

Many electrical devices continue to use power when they are in the OFF position. These devices have what are called "phantom" loads, and include microwaves, coffee makers, televisions, DVD players, chargers, and computers. Devices with LCD or LED displays such as timers and clocks, for example, also use power even when they are turned OFF or are in SLEEP mode. The Kill A Watt™ monitor can be used to measure the phantom loads of electrical devices.

✪ Objective

Students will determine if some electrical devices use power even when they are in the OFF position.

✔ Procedure

1. Select all of the electrical devices in the room that might consume power even when they are turned OFF or in SLEEP mode. Estimate the average number of hours per week each device is ON, OFF, or in SLEEP mode. Record your estimates in the table below.
2. Multiply these values by the number of weeks it is in use per year. Multiply by 52 (total weeks in a year) or 40 (40-week school year) to calculate the average yearly amount of time each device is in use in each mode. Record these values in the table below.
3. Use the Kill A Watt™ monitor to measure the watts used when the device is in the ON, OFF, and SLEEP modes. Record your measurements in the table below.
4. Divide the number of watts used by 1,000 to convert watts into kilowatts.
5. Multiply the hours used per year by the number of kilowatts used. Multiply this number by the cost of a kWh to determine the annual cost of the device in each mode. Record your answer in the table.

Data

Record your measurements and calculations in the table below.

ELECTRICAL DEVICE	HOURS PER WEEK	HOURS PER YEAR	WATTS MEASURED (W)	KILOWATTS (kW)	RATE ($/kWh)	ANNUAL COST
Television (on)	*10*	*400*	*75*	*.075*	*$0.10*	*$3.00*
Television (off)	*158*	*8,216*	*5*	*.005*	*$0.10*	*$4.11*

⁂ Conclusion

- Do some devices use power when they are in the OFF or SLEEP mode?
- How much money could be saved per year by unplugging all of the devices in the room when they are in the OFF or SLEEP mode?

School Building Survey

General Information

1. When was the school built?
2. What changes have been made since the school was built? When were they made?
3. What things use energy on the school grounds? Lighted fields? Outdoor lighting?
4. What fuels are used in the school? For heating, cooling, water heating, lighting, other?
5. How much does the school pay each year for energy? How much for electricity? How much for heat?
6. Are there other energy costs that the school pays for, like buses?
7. How many hours is the school in use each week?
8. Do other groups that use the school pay for the energy they use?
9. Who is in charge of controlling energy use in the school?
10. Who is in charge of maintaining the equipment?
11. Is there a maintenance schedule for all energy-using systems?

Building Envelope

1. What is the building made of? Is it in good condition?
2. In which direction does the building face?
3. How many windows are on each side of the building? Are any windows cracked or broken?
4. Are the windows single or double-paned? Can they be opened? Do the windows have adjustable blinds?
5. How many outside doors are there? Are they insulated? Are there windows in the doors? Are any cracked or broken?
6. Does the building have insulation in the walls and ceiling?
7. Are inside stairwells open or enclosed?
8. Do windows and doors seal tightly, or do they leak air?
9. Are trees placed around the building to provide shade in warm months?
10. Are there awnings or overhangs over the windows to shade windows from the overhead direct sun in warm weather, yet allow the slanted rays in winter to enter?

School Building Survey

Heating/Cooling Systems

1. What kind of heating system is used in the school? What fuel does it use?
2. How old is the heating system?
3. Does the heating system have a programmable thermostat to control temperature? What are the settings?
4. What kind of cooling system is used in the school?
5. How old is the cooling system?
6. Does the cooling system have a programmable thermostat to control temperature? What are the settings?
7. Is there an air exchange system to provide fresh air when the heating and cooling systems are not operating?
8. Are the boilers, pipes, and ducts sealed and insulated?
9. Are the heating and cooling systems maintained on a regular basis?
10. Does your school make use of passive solar heating?

Water Heating

1. What fuel is used to heat water in the school?
2. Is there more than one water heater? How many?
3. How old are they?
4. Do the water heaters have timers?
5. At what temperatures are the water heaters set?
6. Are the water heaters and water pipes insulated?
7. Are there leaks in the hot water system?
8. Are flow restrictions used?

Lighting

1. What kind of lighting is used in the school? Outside the school? Exit lights?
2. Can the lights be controlled with dimmer switches? In which areas or rooms?
3. Does the school make use of skylights and natural lighting?
4. Are there timers for the outside lights so they go off automatically?
5. Are there automatic timers for any of the lights?

Topic Group Questions

The Importance of Energy Management in Schools

1. How much energy does your school use and what energy sources produce it?
2. What are the economic benefits to conserving energy at school?
3. What are the environmental benefits to conserving energy at school?
4. What are the health, safety, and educational benefits to conserving energy at school?
5. Does your school have someone in charge of energy management of the building? If so, what are his/her responsibilities?

Building Envelope

1. Is the building adequately insulated? Ceiling? Walls? Floors?
2. Do all of the doors seal tightly with no air leakage? Are doors left open when heating or air conditioning systems are operating?
3. Are the windows double–paned? Do they seal tightly with no air leakage? Are windows left open when heating or air conditioning systems are operating?
4. Is there a school policy that regulates when doors and windows can be open? Who is in charge of enforcing the policy?
5. Is landscaping used to help conserve energy around your school building? If not, is it a feasible idea?

HVAC Systems

1. Is water heating integrated into your school's HVAC system? If not, how is water heated?
2. What HVAC systems does your school have? What fuels power your HVAC systems?
3. Is your HVAC system regulated by the central district? If not, how is it regulated?
4. Is the temperature of the building regulated for time of day and usage? Are the temperature settings in line with suggested guidelines?
5. Can individual teachers or administrators override the HVAC controls?

Lighting Systems

1. Is daylighting used to reduce the energy consumption of artificial lighting?
2. Does your school have the most energy efficient lighting available? If not, what types of lighting are used?
3. Are lights left on when they are not needed?
4. Are light levels higher than necessary?
5. Does your school use automatic switches, dimmers, and occupancy sensors to reduce energy consumption for lighting?

Appliances and Plug Loads

1. Does your school have a policy concerning the use of energy efficient appliances? Are ENERGY STAR® rated appliances required?
2. Does your school have a policy concerning the management of plug loads?
3. Are machines left on when not in use? If so, which machines?
4. Are staff members allowed to have personal appliances in classrooms and offices? Are these regulated?
5. Are plug loads used with surge protector strips so that phantom loads can be turned off at night?

Topic Group:

Question 1	Question 2	Question 3	Question 4	Question 5

Essential Details	Essential Details	Essential Details	Essential Details	Essential Details

So what? What's important to understand about this?

School Energy Consumption Survey

Even if school buildings are well insulated and have the most modern, efficient energy systems, a significant amount of energy can be wasted if these systems are not controlled and managed wisely. That is where the human element comes in—learning about energy and conservation so that you can use the systems smartly.

Temperature Management

The best heating system in the world cannot operate efficiently 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, temperature control systems should be set at 68°F (20°C) during the heating season and 78°F (25°C) in the cooling season during the day and set back at night for optimum efficiency. Programmable thermostats—with access limited to authorized personnel—are recommended. There should also be policies prohibiting the opening of windows and doors during heating and cooling seasons.

If the temperature of offices and classrooms can be individually controlled, there should be policies on permissible temperature ranges in keeping with the recommendations above. Temperature ranges can vary for different rooms in the school. Gyms, for example, need not be heated to the same temperature as classrooms when physical activity is scheduled. Auditoriums, hallways, storage rooms, and other little used rooms need not be heated and cooled to the same temperature as occupied rooms.

Rooms and areas that have windows in direct sunlight should be equipped with operational blinds that can help control temperature—closed in cooling months and opened in heating months when sunlight is focused on them. Adjustable vents can also help control temperature.

The relative humidity—the amount of moisture—of the air also affects comfort level. The more moisture, the warmer the air feels. Many furnaces and boilers are equipped with humidifiers to add moisture during heating months when cold air carries little moisture. Many cooling systems have dehumidifiers that remove moisture during cooling months, because hot air is capable of holding more moisture. Optimum comfort for relative humidity is between 40-60 percent.

Lighting

Lighting, including the most efficient fluorescent system, is not efficient if it is used indiscriminately. In most schools, more light is used than is necessary in most areas and lights are often left on when areas are not in use. Maximum use of natural lighting should be encouraged. Studies have shown that students learn better in natural light than in artificial light. Partial lighting and dimmer switches should be used where available. All lights not necessary for safety should be turned off when rooms are not in use. The same is true for outside lights. Experiment with light levels in your classrooms and determine optimum levels for different tasks, such as reading and taking notes.

Water Heating

Heating water can use a lot of energy, especially if the water is heated all of the time and at too high a temperature. Water heaters should be equipped with timers and the temperature settings should be regulated according to task. For example, washing hands does not require water as hot as washing dishes. Most water heaters are set much higher than necessary for the task. The water in classrooms and lavatories need not be set higher than 90°F (32°C). In shower rooms, it need not be set higher than 100°F (38°C). Only kitchens may require hotter temperatures for safety purposes. In science labs, it is more efficient to heat water when it is needed than to maintain tap water at high temperatures.

Electrical Appliances

Many computers, VCRs/DVD players, digital projectors, and other electrical appliances draw electricity even when they are turned off. These appliances should be plugged into surge protectors so all of the power can be turned off when they are not in use, or at the end of the day. These surge protectors can also protect equipment against sudden power surges that can damage their electrical systems.

Many copiers and computers have a long warm–up time that makes it difficult to turn them off and on as they are needed. In many schools, however, they are left on 24 hours a day. Turning TVs and VCRs/DVD players off when not in use, and computers and copiers off at the end of the day, can save a significant amount of energy.

SCHOOL ENERGY CONSUMPTION SURVEY

Recording Form

Date ____________________ Time _____________ Outdoor Temperature ______________________________

Outdoor Relative Humidity ___________________ Weather ____

Is The Heating Or Cooling System In Use? ____

Classroom/Common Area # ________________

Classroom Use Empty In-Use

Number of Windows ____________

Indoor Temperature ____________

Relative Humidity ____________

Is There a Thermostat? Yes No

Are There Adjustable Vents? Yes No

Are the Windows Open? All Some None

Hot Water Temperature ____________

Are the Faucets Dripping? All Some None

Types of Lighting ______________________________

Light Meter Reading ____________

Type of Light Ballasts ____ Electronic ____ Magnetic N/A

Are There Adjustable Lights? Yes No

Are the Lights On? All Some None

Are the Blinds Closed? All Some None

Are the Doors Tightly Closed? Yes No

List the electrical appliances that are turned on.

Are the appliances/devices in use?

Other Comments:

Classroom/Common Area # ________________

Classroom Use Empty In-Use

Number of Windows ____________

Indoor Temperature ____________

Relative Humidity ____________

Is There a Thermostat? Yes No

Are There Adjustable Vents? Yes No

Are the Windows Open? All Some None

Hot Water Temperature ____________

Are the Faucets Dripping? All Some None

Types of Lighting ______________________________

Light Meter Reading ____________

Type of Light Ballasts ____ Electronic ____ Magnetic N/A

Are There Adjustable Lights? Yes No

Are the Lights On? All Some None

Are the Blinds Closed? All Some None

Are the Doors Tightly Closed? Yes No

List the electrical appliances that are turned on.

Are the appliances/devices in use?

Other Comments:

Energy Management Plan

A comprehensive energy management plan for a school should have several components:

- Renovations to the building and energy systems to make them operate more efficiently.
- Control and management of the energy systems so they are used only when necessary and at prescribed settings.
- Modification of behaviors of all of the consumers in the school—administrators, students, teachers, and janitors, as well as community members who use the facility.

Building and Energy System Renovations

There will be few building renovations that you as students can accomplish yourselves, except for perhaps minor repairs such as replacing broken windows, caulking, weatherstripping, and planting shade trees. Depending on how comprehensive the plan will be, you can research major renovations and new systems with their costs and payback periods, or simply prioritize the school's needs and make recommendations for improvements.

Your energy management plan should include improvements to the building envelope, as well as improvements to the heating, cooling, lighting, and hot water heating systems. The building survey you did will point out the major deficiencies. You need to prioritize those problems and decide what changes can realistically be made in the short term and what long-term goals the school should have for increasing efficiency.

If the heating system is 25 years old, it might make sense to recommend replacing it with a new, high-efficiency system, showing how quickly the cost of the system will be paid back with energy savings. If, on the other hand, the system is only ten years old, replacing the system might be a long-term goal, even if it is not as efficient as new systems.

System Control and Management

You can have a significant impact on energy conservation by controlling and managing the energy systems in your school—determining optimum temperature settings, maintenance schedules, and policies for control of the energy systems. Be sure you consider outside areas and common areas, as well as classrooms and offices.

Installing inexpensive timers and programmable thermostats to control systems and reducing the number of people with access to controls can make a major difference. Installing blinds on windows in the direct sun and installing vents that can be opened and closed are additional ideas. Can dimmer switches be used with the light system in your school? Some fluorescent systems can be dimmed, others cannot.

Look at the results of the *School Building Survey* and the *School Energy Consumption Survey* to show you where the major deficiencies are, then prioritize the problems. If every room in the school has a window air conditioner, it is much harder to control usage than if there is a central system.

Behavior Modification: Teaching Others

Changing the way people use energy can result in significant energy savings. Shut off the lights every time you leave a room. Do not leave hot water faucets running or dripping—turn them off completely. Keep windows and doors closed when the heating and cooling systems are on. Use natural lighting. Turn computers on only on days when you need them. The list goes on and on.

You can make a big difference in school energy consumption by developing a campaign to educate school consumers about conservation practices. Develop a plan for teaching everyone what you have learned from the *School Building Survey* and *School Energy Consumption Survey*, and show them what they can do to save energy. Show them how saving energy helps protect the environment. Show them how saving energy saves money.

How will you get the message out? An article in the school newspaper? A video PSA? A special assembly? Posters in the halls? Announcements over the PA system? How will the program be reinforced throughout the year? A good education program must be ongoing or consumers will fall back into old energy-wasting habits.

A program to return the money saved to the school for educational programs can be an incentive for encouraging energy-saving behaviors. What other incentives might be effective?

Building Envelope

Importance

HVAC Systems

Energy Management Plan

Lighting

Priorities

Appliances

Learning and Conserving Glossary

appliance	any piece of equipment, usually powered by electricity, that is used to perform a particular function; examples of common appliances are refrigerators, clothes washers, microwaves, and dishwashers
compact fluorescent	a light bulb consisting of a gas-filled tube and a magnetic or electronic ballast; electricity flows from the ballast through the gas, causing it to give off ultraviolet light; the ultraviolet light excites a white phosphor coating on the inside of the tube, which emits visible light; compact fluorescent light bulbs use less energy and produce less heat than a comparable incandescent bulb
conduction	the transfer of thermal energy from one particle to another through vibrations in a solid
convection	the transfer of thermal energy from one particle to another by movement in a fluid
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)
energy	the ability to do work or make a change
energy conservation	saving energy through behavior changes and installing energy efficient devices
energy efficiency	the ratio of the energy delivered by a machine to the energy supplied for its operation; often refers to reducing energy consumption by using technologically advanced equipment without affecting the service provided
ENERGY STAR®	a Federal Government program that recognizes the most energy efficient machines with a logo
energy sustainability	meeting energy demands without affecting the needs of others for the future
EnergyGuide label	the label on an appliance that shows how much energy the appliance uses in comparison to similar appliances
fluorescence	emission of light by a gas that has absorbed electromagnetic radiation
halogen	a type of incandescent light bulb that uses a small amount of a halogen gas and a filament; slightly more efficient than traditional incandescent bulbs
hygrometer	an instrument used to measure the moisture content, or humidity, of an environment
incandescent	a type of electric light in which light is produced by a filament heated by electric current; the most common example is the type you find in table and floor lamps
infiltration	to pass into or through
insulation	a material used to separate surfaces to prevent the transfer of electricity, heat, or sound
Kill A Watt™ monitor	a device that measures the amount of electrical energy used by a machine
kilowatt	a unit of power, used to measure electric power or consumption; a kilowatt equals 1,000 watts
kilowatt-hour (kWh)	a measure of electricity, measured as one kilowatt (1,000 watts) of power expended over one hour
landscaping	the use of plants to modify or ornament a natural landscape
light emitting diodes	energy saving bulb that generates light through the use of a semiconductor
lumen	a measure of the amount of light produced by a bulb
nonrenewable energy source	fuels that cannot be renewed or made again in a short period of time, such as petroleum, natural gas, coal, propane, and uranium
payback period	the length of time you must use a more expensive, energy efficient appliance before it begins to save you money in excess of the additional upfront cost

phantom load	a device that draws electric power when not in use or powered on
plug load	a plugable device
R-value	a measure of a material's resistance to heat flow in units of Fahrenheit degrees x hours x square feet per Btu; the higher the R-value of a material, the greater its insulating capability
relative humidity	ratio of moisture in the air compared to what the air can hold at the temperature
renewable energy source	fuels that can be made or used again in a short period of time, such as solar, wind, biomass, geothermal, and hydropower; see also nonrenewable energy source
semiconductor	a material that has a conductivity level between an insulator and a conductor
therm	a measure of the amount of thermal energy (or heat) that can be produced by natural gas
thermostat	a device that controls the amount of heating and cooling produced and/or distributed
watt	a unit of measure of power
weatherization	to make a building better protected against the effects of weather

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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PECO
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Peoples Gas
Petroleum Equipment and Services Association
Phillips 66
PNM
Providence Public Schools
Read & Stevens, Inc.
Renewable Energy Alaska Project
Rhode Island Office of Energy Resources
Robert Armstrong
Roswell Geological Society
Salt River Project
Salt River Rural Electric Cooperative
Saudi Aramco
Schlumberger
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Shell
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Sigora Solar
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Society of Petroleum Engineers – Middle East, North Africa and South Asia
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U.S. Energy Information Administration
Yates Petroleum Corporation