Using and Saving Energy in the House System

Constellation
An Exelon Company

Building Envelope

The transfer of heat, air, and moisture into and out of the home is largely governed by the building envelope, which is made up of all the components that separate the inside of the home from outdoors. Siding, windows, doors, and roofs have an important role to play, as does how tightly the various parts of the building are sealed to one another.

▪ Insulation

Insulation in the walls and attics plays a very important role in controlling heat transfer. Insulation is effective because it contains many, tiny air pockets. When thermal energy has to move through trapped air it is slowed down because air does not conduct heat very well compared to most materials. This is because air molecules are farther apart from one another than the molecules in solids or liquids. Materials used for insulation are effective because they create these air pockets. Most types of insulation only slow heat transfer via conduction. In these materials, thermal energy can still transfer through via convection.

The type of insulation used is determined by both where it will be used and how much it costs. There are many types of insulation used in buildings today.

- Cellulose is made from ground up newspaper that is treated with a flame retardant to minimize risk from fire. It comes in large bales and is installed using a machine that blows the insulation through a hose.

  It is common to see this type of insulation in attics as loose fill. It is also used to insulate walls in homes that have no insulation in these locations. In walls, cellulose is packed tightly enough into the cavity that it also stops air movement preventing heat transfer via convection.

- Fiberglass insulation is made of tiny threads of glass that are meshed together. Fiberglass insulation is most used in long rolls called batts. Sometimes there is a paper or foil facing on one or both sides of the roll. The rolls are sized so that batts fit snugly between the rafters or wall studs of most homes. Some forms of fiberglass insulation can also be blown into an attic or a wall just like cellulose.

- Foam insulation comes in many forms. Some foam insulation comes as a liquid and is sprayed or blown like cellulose. However, it may not be used in enclosed walls the way cellulose and fiberglass can. Other types of foam insulation are provided as solid boards. These are useful for attaching to walls and ceilings. Some types of foam insulation can stop air movement, preventing heat transfer via convection.

The effectiveness of insulation is measured by R-value. R-value is the rating that is used to indicate the resistance of the material to heat transfer. The higher the R-value, the more effective the material is at reducing heat transfer.

No matter what type of insulation is used, it has to be installed properly. Insulation that gets compressed is much less effective because so many of the trapped air spaces have been eliminated. Another common way that insulation's effectiveness is reduced is when there are gaps.

CELLULOSE INSULATION

Image courtesy of Community Services Consortium

FIBERGLASS INSULATION

Image courtesy of Owens Corning

Insulation R-Value

Insulation Type	R-Value Per Inch of Insulation	Typical Applications
Cellulose, loose fill	3.7	Attic Floor
Cellulose, high density	3.2	Walls, Enclosed Cavities, Framing Transitions
Fiberglass, batts	3.0	Basement Ceiling, Open Stud Walls, Attic Floor
Foam board	7.0	Foundation Walls, Attic Access Doors

Data: Building Performance Institute

▪ Air Sealing

Air, carrying thermal energy with it, can leak in or out through small cracks. Often the many small cracks in a home add up to a hole the size of a wide open door. Some of these cracks are obvious—around doors and windows, for instance. But others are hidden behind walls and above ceilings. Due to the stack effect, in colder climates, the attic floor is usually the place where the most air leaks out of a house. Unseen cracks and hidden air pathways inside the home can be the largest sources of uncontrolled heat transfer in the house.

To prevent air leaks, caulk, seal, and weather-strip all cracks and openings to the outside. Some of these cracks can be sealed by the homeowner, but the greatest savings will be gained by hiring a company specializing in finding and sealing hidden leaks in the attic.

▪ Doors and Windows

Doors and windows are an important part of the building envelope. They allow occupants easy access between the inside and outside world, but these are also areas that should be checked carefully to ensure that they are working efficiently.

The best windows shut tightly and are constructed of two or more pieces of glass. Any cracks around the window frames should be caulked and the windows checked often to make sure they seal tightly. Any cracked glass should be replaced. In some double-paned window systems, a heavy gas is used to fill the space between the panes. This gas slows down heat transfer by convection. Some windows also have coatings that allow sunlight in, but are effective at reflecting thermal energy radiating from within the building back inside.

Older windows in a home can be treated to make them more energy efficient. Weatherstripping can be used to create a tighter seal between the window and the frame. There are many types of weatherstripping. For windows, use a spring-type weatherstripping, which is a strip installed along the window frame on the track on which the window moves up and down. The most durable type is made of brass. It is a strip folded in half so as to spring against both the window and the frame creating a tight seal. Foam weather-stripping, while not as effective, is easy to find and install.

Doors to the outside should seal tightly and have door sweeps at the bottom, as well as weatherstripping around the frame to prevent air leaks. Use rubber "stop-type" weatherstripping for doors. This is installed in the frame as a strip and has a thick "bulb" that squeezes tightly into the crack when the door is closed. Door sweeps are flexible, rubber strips that are installed at the bottom of a door to prevent air movement under the door. If the door has windows in it, they should be sealed tightly.

It's a System...

Sealing a home to save energy can cause problems with moisture and indoor air quality if not done properly.

AIR SEALING MATERIALS

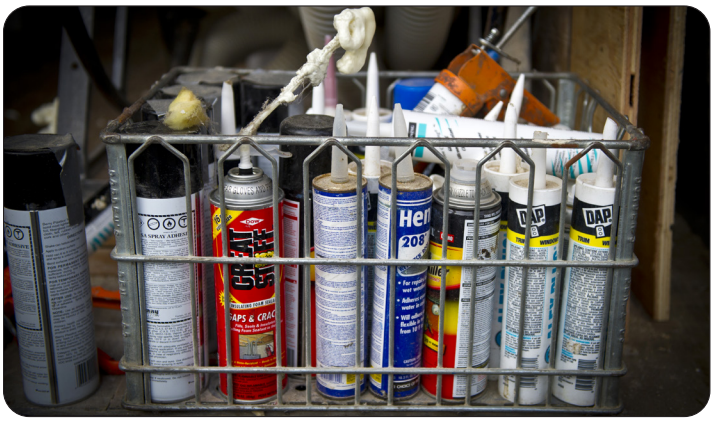
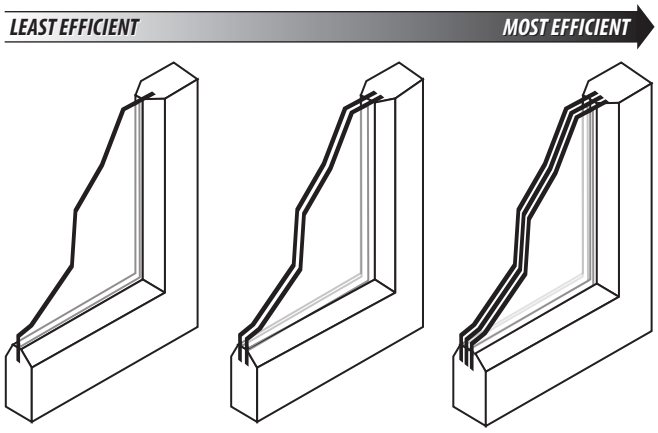


Photo Credit: Dennis Schroeder, NREL

Window Glazing Types



SINGLE
often has storm window, screen, or combination

DOUBLE
space between glass may be gas-filled
glass may be low-E type

TRIPLE
space between glass may be gas-filled
glass may be low-E type

INSTALLING A DOOR SWEEP

▪ Materials and Techniques Used by Installers

Homeowners can take many different measures to improve the building envelope. You can conduct an informal home audit to determine where there might be problems with the building envelope. You may already be aware of problem areas if a room always feels hotter or colder than the others.

Individuals can fill in small cracks with caulk. When remodeling, the proper insulation can be chosen for the space, and weatherstripping can be added around door frames and windows to fill in spaces where larger amounts of air are getting through.

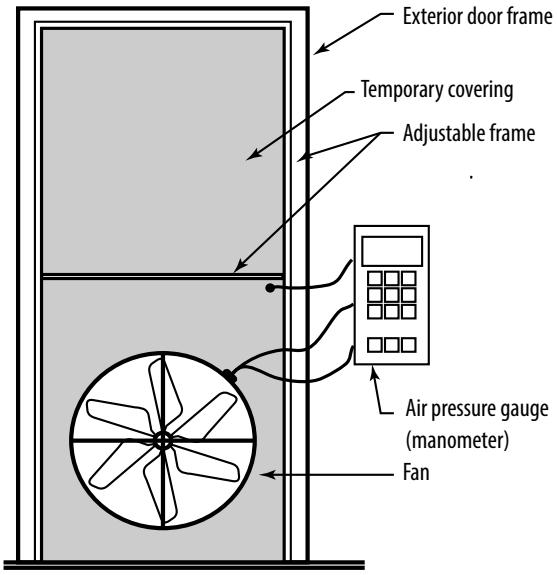
In some cases, the building envelope needs more extensive work and it is best to hire a professional. Because of the stack effect, this work usually focuses on the attic. Installers use a variety of materials to seal hidden air pathways. Caulk, liquid foam, foam board, and sheet metal are some examples. Whatever material is used, the installer ensures that a barrier is used that does not allow air to pass through it and that it is sealed in place with an airtight sealant such as foam or caulk.

When a home is built or when an existing home is sealed, it is necessary to keep in mind the need for fresh air for those who live there. While even after air sealing most homes have enough natural air leakage to provide healthy indoor air, some houses might need to add exhaust fans or more elaborate systems. A home performance professional will test a house before any work is done to see how leaky the house is and then will test it again after sealing to make sure it is safe for those living there. This is done with a device called a blower door. A variable speed fan and air gauges are used to measure the amount of air moving through the fan as well as the difference in pressure between inside and outside. A technician will close all doors and windows to seal the building as tightly as possible and then pull air out of the house using the fan. This forces air in through all of the hidden leaks. The measurements taken from the gauges allow the technician to quantify the leakage and compare it to standards in order to determine if a house is too leaky or too tight. This test is conducted before sealing the house and again afterwards. Sometimes it is even used while the house is being air sealed to give the crew feedback on the effectiveness of their efforts.

Another tool used is an infrared (IR) camera. An IR camera is a device that forms an image using infrared radiation. It is similar to a regular camera that forms an image using visible light, but instead senses longer wavelengths of energy that indicate radiant heat transfer. Using the IR camera, the home performance professional can find areas of heat loss or heat gain in a home. When used with the blower door, the IR camera can also show hidden air leakage paths inside the walls and floor cavities of the house.

Diagnostic Tools

Testing the airtightness of a home using a special fan called a blower door can help to ensure that air sealing work is effective. Often, energy efficiency incentive programs, such as the DOE/ EPA ENERGY STAR® Program, require a blower door test to confirm the tightness of the house.



INFRARED CAMERA

The dark strip in the middle of the camera screen indicates that the wall at the corner of the room is colder. In most homes there is less insulation in corners leading to increased heat transfer in these areas.

It's a System...

If a home is well insulated and sealed, it can use a smaller heating system, which will use less energy.

HVAC

Heating and cooling systems use more energy than any other systems in our homes. Natural gas and electricity are used to heat most homes, and electricity to cool almost all. About 43 percent of the average family's energy cost is for keeping homes at comfortable temperatures. The energy sources that power these heating and cooling systems also emit carbon dioxide into the atmosphere each year, which contributes to the greenhouse effect.

In most furnaces and boilers, natural gas, heating oil, or propane is burned to heat the home. In a furnace, air is heated and then distributed to the home through ductwork to heating registers in rooms. Return air registers bring air back to the furnace from the home to be reheated. Boilers, however, heat water instead of air. Hot water, or sometimes steam, is distributed to the house through pipes. In the case of boilers, pumps move the water. In steam systems, the steam pressure itself causes the steam to move through the pipes. In either case, pipes return water to the boiler where it is reheated and re-circulated. Today's high efficiency boilers and furnaces are rated 20 percent more efficient than older appliances.

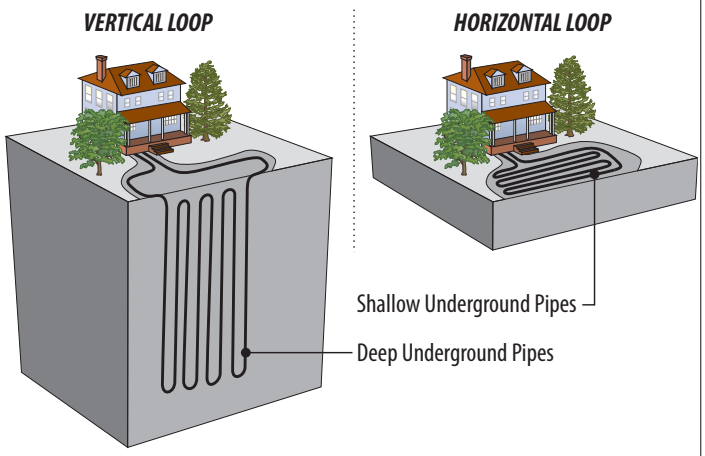
Electric heaters are also used in many homes. Most heaters are installed as long radiators that run along the bottoms of the walls and are wired into the home's electrical system. Other, smaller heaters are portable and can be plugged into the wall. In an electric heater, electricity is passed through a wire that resists the current, heating the wire. Electric heat warms up a room quickly and quietly, but it is very expensive.

Air conditioners (AC) are designed to move large amounts of heat out of the house. Window air conditioners can provide cooling in individual rooms, while central air conditioners cool entire homes. Air conditioning is very energy-intensive, so it's important to use it efficiently by using efficient temperature settings and keeping the system maintained. The best way to save when cooling is to use the AC as little as possible. Effective cooling strategies include:

- **Air Control**—Use convective heat transfer to cool by opening windows overnight if it cools off. In the morning, close windows before it heats up.
- **Sun Control**—Stop radiant heat transfer from the sun during the daytime, by closing shades. This can also be done by installing awnings or planting trees on the south side of the house.
- **Fans**—When opening windows on cool evenings, put a fan in the window to pull cool air through the house. Use a ceiling fan to circulate air in a room. Also, if you point a fan directly at you, it will keep you cooler and allow you to be more comfortable at higher temperatures.

Heat pumps and geothermal systems work very similar to air conditioning. The difference is that these units can reverse the direction of heat transfer in the winter to heat the home. That is, they can absorb thermal energy from outdoor air (or from the ground in a geothermal system) and bring it indoors. Heat pumps are the most efficient form of electric heating in moderate climates. When properly installed, a heat pump can deliver 1.5 to 3 times more heat energy to a home than the electrical energy it consumes.

Residential Geothermal Exchange Units



Geothermal heat pumps use the constant temperature of the earth as an exchange medium for heat. Although many parts of the country experience seasonal temperature extremes—from scorching heat in the summer to sub-zero cold in the winter—the ground a few feet below the earth's surface remains at a relatively constant temperature.

Depending on the latitude, ground temperatures range from 45°F (7°C) to 75°F (21°C). So, like a cave, the ground's temperature is warmer than the air above it during winter and cooler than the air above it in summer. Geothermal heat pumps take advantage of this by exchanging heat with the earth through a ground heat exchanger.

Thermostats are used to control the heating and cooling systems in a home. Most consumers set the temperature higher than recommended during heating seasons and lower than recommended during cooling seasons, wasting energy. A temperature setting of 68°F (20°C) during the day and 58-60°F (14-15°C) at night during heating seasons is comfortable if people dress warmly and use warm blankets. During cooling seasons, a temperature setting of 78°F (25°C) is comfortable if people dress appropriately and use fans.

Programmable thermostats automatically control the temperature of buildings for time of day and can save energy and money, when programmed correctly, by automatically adjusting the temperature for times of the day when no one is home or when people are sleeping. Adjusting the thermostat by just two degrees can decrease bills significantly and prevent hundreds of pounds of carbon dioxide from entering the atmosphere each year.

Water Heating

Water heating is the second largest energy expense in most homes, accounting for 16 percent of energy use on average. Usually water is heated in a tank-type water heater that is fueled by natural gas or electricity. Heated water is used for showers, hand washing, dishwashing, and cleaning. The five main ways to reduce water heating bills are:

- Use less hot water
- Make sure there are no water leaks or drips
- Turn down the thermostat on the water heater
- Insulate water heaters and water pipes
- Choose an energy efficient water heater when yours needs replacing

The easiest way to cut the cost of heating water is to reduce the amount of hot water consumed. This can be done with little cost and minor changes in lifestyle. Water-saving faucet aerators (which diffuse the flow of water) can be installed in bathrooms and kitchens. Water-saving showerheads are also available. They limit the flow of water while providing adequate flow for washing.

Most water heater thermostats are set much higher than necessary. A setting of 120 degrees Fahrenheit provides hot water suitable for most uses. Decreasing the temperature by 10 degrees Fahrenheit can result in energy savings of $12 to $30 per year. Buying a high efficiency or tankless water heater can save $40-$140 per year. Instead of heating a large amount of water and keeping it hot in a tank, these appliances only heat the water as it is being used.

Lighting

Legislation under the Energy Independence and Security Act put restrictions on light bulbs and increased the energy efficiency requirements for bulbs sold in the U.S. These changes began a phase-out of traditional incandescent bulbs. Consumers now have many more efficient choices of halogen incandescents, compact fluorescent light bulbs (CFLs), and light emitting diodes (LEDs). Their widespread use has helped to bring prices down on all types of energy efficient lighting.

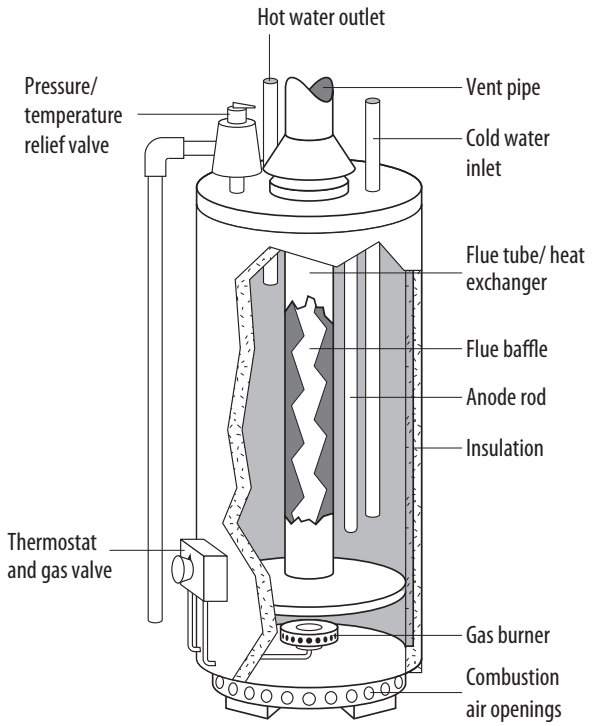
However, some homes are still lit with traditional incandescent light bulbs. Only 10 percent of the energy consumed by an incandescent bulb produces light; the rest is given off as heat. This is because light is produced by sending electricity through a filament that resists the current. This causes the filament to heat up and then glow.

Energy saving halogen incandescent bulbs are more energy efficient than traditional incandescents. Inside a halogen bulb, the filament is encapsulated and surrounded by halogen gas, increasing bulb efficiency. Halogen incandescent bulbs are available in a wide range of shapes and colors at hardware and home improvement stores.

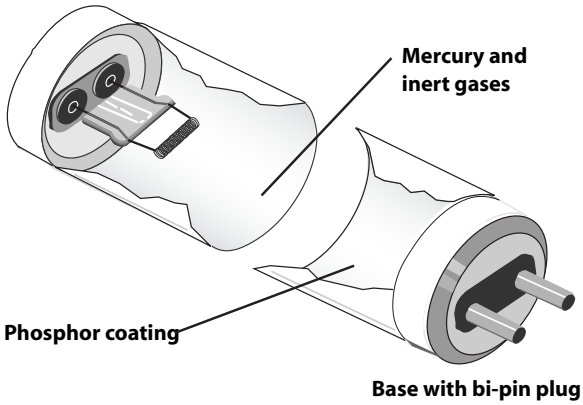
CFLs work on a much different principle and have become more common. A fluorescent light is a glass tube with a powdered phosphor coating on the inner surface. The tube is filled with a gas and contains a small amount of mercury.

Electrodes are at the ends of the tube. An electric current is passed from one electrode to the other, turning some of the mercury atoms into vapor that emits rays of ultraviolet (UV) light. When these invisible UV rays strike the phosphor coating, the phosphor atoms

Storage Water Heater

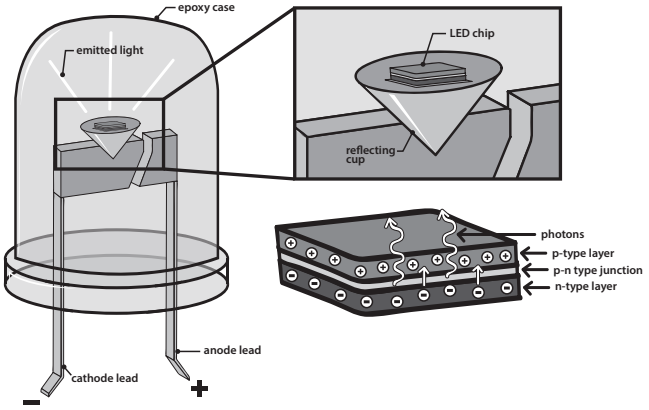


Fluorescent Tube Lamp



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.

Inside an LED



emit visible light. The conversion of one wavelength of radiant energy into another is called fluorescence. Fluorescent tubes produce very little heat and are much more energy efficient.

CFLs are now about the same price as energy-saving halogen bulbs. They save money in the long run because they use only one-fourth the energy of incandescent bulbs and last 7-10 times longer. Installing CFLs will save you money in utility costs and reduce your carbon emissions.

LEDs, which have been commonly found in traffic lights, exit signs, car tail lights, and other applications, are also widely available as affordable options for home lighting. They contain no mercury and offer even more energy savings than CFLs. They last even longer than CFLs, they turn on instantly (some older CFLs take a moment to come on and some can take a few moments to warm up), and many of them can be used with a dimmer or even app-based programs. LED bulbs often cost less than CFL bulbs, while providing even more energy savings.

Ways to save with lighting:

- Turn off lights when not in use
- Use day lighting whenever possible
- Use task lighting—instead of lighting the whole room provide light where it is needed
- Use CFLs or LED lighting instead of incandescent

It's a System...

Using traditional incandescent light bulbs can increase energy use by your air conditioning since they produce so much heat.

Appliances and Electrical Devices

Electrical devices account for percent over 30 of the average household's energy consumption, with refrigerators, televisions, cable boxes, clothes washers, and clothes dryers at the top of the consumption list. Home electronics and home office machines are also a significant and growing category of electricity users.

Refrigerators

The easiest way to save energy with your refrigerator is through temperature settings. Most people keep their refrigerators colder than necessary. Setting the temperature in the "Smart Zone," 38-40 degrees, ensures that you use the minimum amount of energy to keep your food fresh. The freezer should be set to 5 degrees, while stand alone freezers should be set to 0 degrees for long term storage. Also, energy can be conserved by making sure the cold air inside the refrigerator stays there. Minimize the time that the refrigerator door is open by deciding what you want before opening the door. Also, check your refrigerator door seals to see if they are airtight. Test them by closing the door over a piece of paper so it is half in and half out. If you can pull the paper out easily, the latch may need adjustment or the seal may need replacing. If the appliance is more than 10 years old, you might consider buying a new unit.

Laundry

Electric clothes dryers can often use 5,000 watts of electricity. That's the same as operating fifty 100 watt light bulbs. Drying only full loads, cleaning the lint filter after each load, and not over-drying your clothes are three effective ways to save. The dryer vent hose should also be cleaned periodically to ensure that lint is not building up and blocking the vent. Blockages in the vent hose cause the dryer to work harder, use more energy, and can also be a fire hazard. Newer dryers will sense when the laundry is dry and shut off automatically, saving energy.

Ninety-percent of the energy used by clothes washers is for heating the water. Using cold water detergents will allow you to wash in cold water, saving significantly on laundry costs. Another way to save is by only washing full loads. Newer, "horizontal axis" front-loading washing machines spin at a much higher rate, removing more water from clothes than regular, top-loading machines. This means clothes need less time in the dryer.

Computers/Electronics

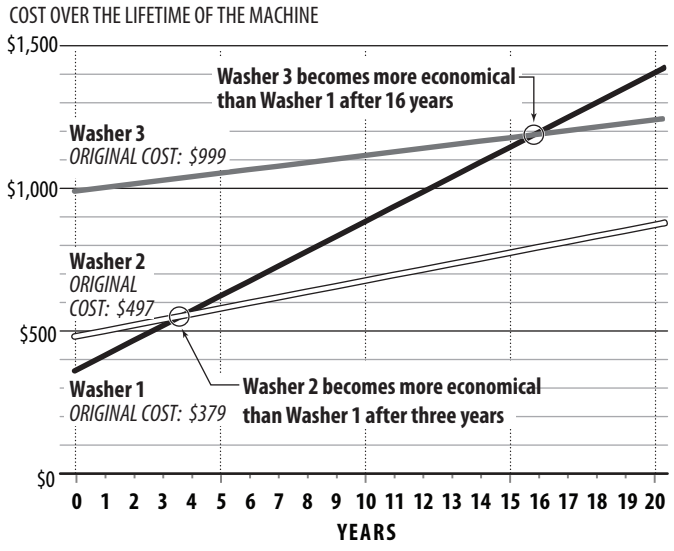
One of the easiest ways to save energy with computers, printers, and monitors is to simply turn them off when they are not in use, rather than leaving them in a "sleep" or "standby" mode. Turning computers off saves energy and will not harm the equipment.

Washing Machine Payback Period

Spending a little bit more money on an energy efficient appliance could save you several hundred dollars over the lifetime of the product. The payback period could be shorter than you think!

	WASHER 1	WASHER 2	WASHER 3
Original Cost	$379	$497	$999
Estimated Annual Electricity Use	427 kWh	160 kWh	102 kWh
Price of Electricity (per kWh)	$0.12	$0.12	$0.12
Operating Cost per Year	$51.24	$19.20	$12.24

Data: NEED Analysis of washing machine EnergyGuide labels



Check to see that the computer's power options are set to save energy during periods the computer is on, but not being used. Screensavers should be disabled, too, as they keep the monitor on instead of allowing it to go into a sleep mode.

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

Phantom loads exist in many electronic or electrical devices found at home. Equipment with electronic 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. These devices can consume anywhere from 1-40 watts even when turned off. You can use a watt meter to see if devices are using power when they are turned off. These devices can be plugged into a smart power strip, which can turn off multiple devices when the strip is not in use.

Shopping for New Appliances and Electronics

When you shop for a new appliance, consider both price tags. The first one covers the purchase price. The second price tag is the cost of operating the appliance. You'll pay the second price tag on your utility bill every month for as long as you own the appliance. An energy efficient appliance will often cost more, but will save money in energy costs. An energy efficient model is almost always a better deal.

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

Equipping our homes only with products with the ENERGY STAR® label, will reduce our energy bills, as well as greenhouse gas emissions by a significant amount. A list of appliances meeting energy efficient standards can be found on the ENERGY STAR® website at www.energystar.gov.

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

Ways to save with appliances and electronics:

- Turn off equipment and appliances when not in use
- Set refrigerator and freezer temperatures in the "Smart Zone"
- Wash and dry full loads of laundry
- Use a cold water clothes wash cycle
- Enable power management settings on computers/peripherals and disable screensavers
- Use power strips to eliminate "phantom loads"

Electrical Devices

Television

DVR

Laptop

Game Console

DVD Player

These are common electrical devices that continue to draw power even when they turned off. Cutting off power completely will save energy and money. Do this by unplugging the device or using a power strip.

ENERGYGUIDE LABEL