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ENERGY EFFICIENCY AND RENEWABLE ENERGY CLEARINGHOUSE

Saving Energy with Electric Resistance Heating

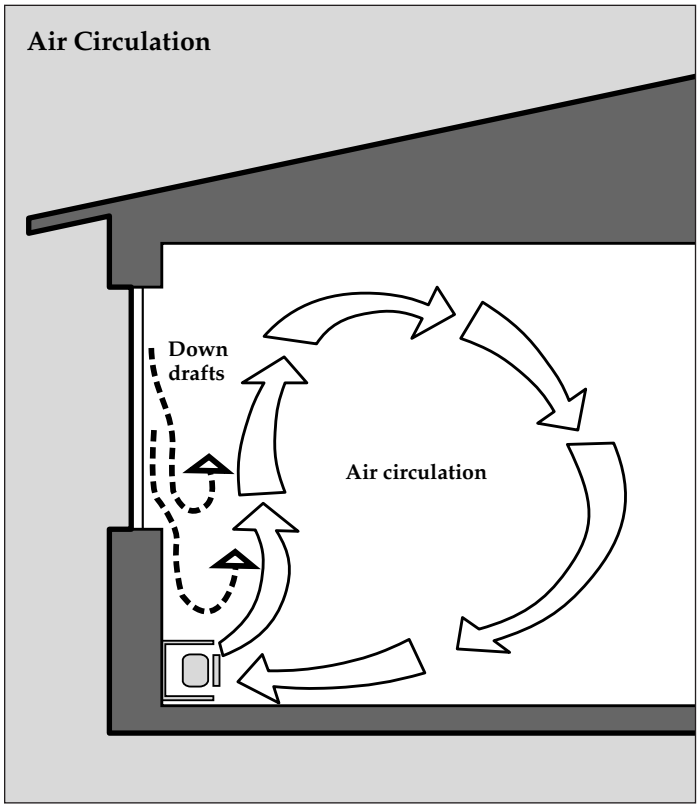
Electricity is a versatile but precious energy source. Because it is needed for refined power equipment such as computers and medical machinery, when it is used for less-refined needs such as heating it should be used as efficiently as possible. If you use electricity for heating your home, this publication will help you save money and minimize your energy consumption when using electrical heating systems. It covers the different types of electric heating, but electric heat pump technologies are not specifically addressed in this publication. Contact the Energy Efficiency and Renewable Energy Clearinghouse (EREC—see *Source List*) for more information on heat pump systems.

Electric Resistance Heat

Electric resistance heating converts nearly 100% of the energy in the electricity to heat. However, most electricity is produced from oil, gas, or coal generators that convert only about 30% of the fuel's energy into electricity. Because of electricity's generation and transmission losses, electric heat is often more expensive than heat produced in the home with combustion appliances, such as natural gas, propane, and oil furnaces.

Electric resistance heat can be supplied by centralized forced-air furnaces or by zonal heaters in each room, both of which can be composed of a variety of heater types. Zonal heaters distribute electric resistance heat more efficiently than electric furnaces because you set room temperatures according to occupancy. In addition, zonal heaters have no ducts that can lose heat before it reaches the room. However, electric furnaces can accommodate central cooling easier than zonal electric heating, because the air conditioner can share the furnace's ducts.

Electric resistance heat can be provided by electric baseboard heaters, electric wall heaters, electric radiant heat, electric space heaters, electric furnaces, or electric thermal storage systems.



Naturally circulating warm air from a baseboard heater counteracts cool drafts from the window.

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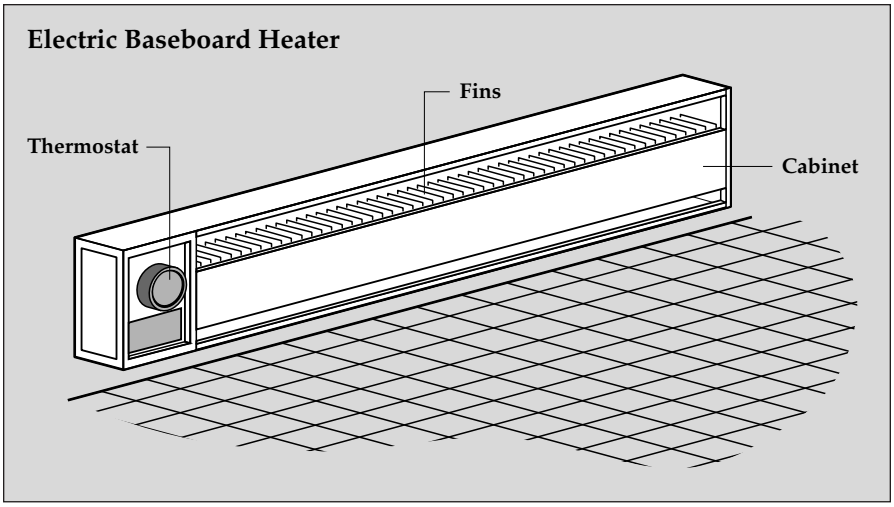
Electric Baseboard Heaters

Electric baseboard heaters are zonal heaters controlled by thermostats located within each room. Baseboard heaters contain electric heating elements encased in metal pipes. The pipes, surrounded by aluminum fins to aid heat transfer, run the length of the baseboard heater's housing, or cabinet. As air within the heater is warmed, it rises into the room, and cooler air is drawn into the bottom of the heater. Some heat is also radiated from the pipe, fins, and housing.



The baseboard heater's electric heating elements are surrounded by metal fins. These fins help to heat air circulating through the heater's cabinet. Built-in thermostats are satisfactory for small rooms or seldom-used rooms, but larger rooms need remote thermostats for adequate comfort

Electricity is a versatile but precious energy source that we need to use wisely and conserve whenever possible.

Baseboard heaters are usually installed underneath windows. There, the heater's rising warm air counteracts falling cool air from the cold window glass. Baseboard heaters are seldom located on interior walls because standard heating practice is to supply heat at the home's perimeter where the greatest heat loss occurs.

Baseboard heaters should sit at least three-quarters of an inch (1.9 centimeters) above the floor or carpet. This is to allow the cooler air on the floor to flow under and through the radiator fins so it can be heated. The heater should also fit tightly to the wall to prevent the warm air from convecting behind it and streaking the wall with dust particles.

The quality of baseboard heaters varies considerably. Cheaper models can be noisy and often give poor temperature control. Look for labels from Underwriter's Laboratories (UL) and the National Electrical Manufacturer's Association (NEMA). Compare warranties of the different models you are considering.

Electric Wall Heaters

Electric wall heaters consist of an electric element with a reflector behind it to reflect heat into the room and usually a fan to move air through the heater. They are usually installed on interior walls because installing them in an exterior wall makes that wall difficult to insulate.

Electric Radiant Heat

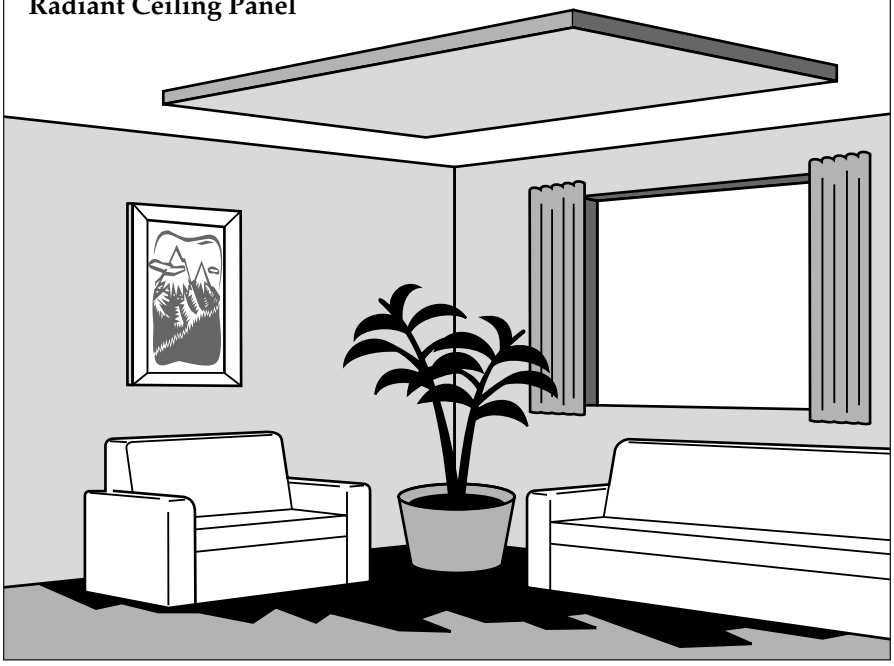
Electric furnaces and baseboard heaters circulate heat by moving air. In contrast, radiant heating systems radiate heat to the room's objects, including its people. For example, you can feel a ceiling-mounted radiant heating panel warming your head and shoulders if you stand underneath it.

There are several types of electric radiant heaters. The most common are electric heating cables imbedded in floors or ceilings. Other radiant heating systems use special gypsum ceiling panels equipped with factory-imbedded heating cables. Newer ceiling-mounted radiant panels made of metal provide radiant heat faster than other types because they contain less material to warm up.

Radiant heat offers draft-free heating that is easily zoned. Unlike other heating systems, it occupies no interior space. This allows you complete freedom to place furniture without worrying about impeding air flow from floor registers or baseboard heaters. Manufacturers claim that radiant heat can provide comfort similar to other systems at lower indoor air temperatures, saving around 5% of space heating costs.

Critics of radiant heat say that it can be difficult to control air temperature with a thermostat. The large heat-storage capacity of the concrete or plaster surrounding the heating cables may result in greater-than-normal fluctuations in the room air temperature, since it takes quite a while to heat up the storage mass. Also, some

Radiant Ceiling Panel



Heat radiates from the ceiling to people and objects in the room, rather than depending on air circulation. Radiant ceiling panels give almost instant comfort, allowing residents to turn heaters on and off like lights.

Electric radiant heat offers draft-free warmth that is easily zoned to heat different parts of the house at different times.

occupants complain about their heads being too warm in rooms that utilize ceiling radiant heat.

Supplying heat at the ceiling or floor, which are locations that typically border the outdoors or unheated spaces, can result in greater heat losses. For example, if there are any flaws in a heated concrete slab or gaps in the ceiling insulation above heating elements, a significant percent of the electric heat may escape to the outdoors without ever heating the home.

Electric Space Heaters

Electric space heaters come in a wide variety of models, either built-in or portable. These heaters may have fans to circulate heated air and may also be designed to transfer some of their heat by radiation. All of these heaters must be given adequate clearance to allow air to circulate safely.

Portable space heaters, as well as many built-in space heaters for small rooms, have built-in thermostats. Larger rooms heated with built-in electric space heaters should have low-voltage thermostats installed in an area that maintains the room's average temperature (see the section "Thermostats for Electric Heating" on page 7).

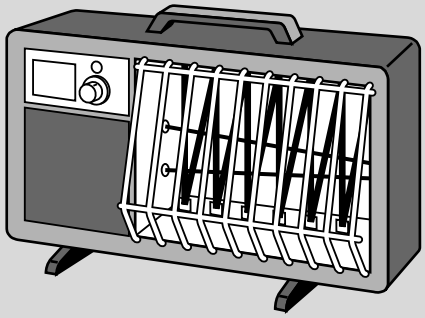
Portable electric space heaters can pose a significant safety hazard unless they have safety features and are used properly. Many cheaper or older portable electric space heaters are not safe for most home uses. Their red-hot elements and lack of safety features can lead to fires. When buying a portable electric space heater, select one with all of these safety features:

- tip-over switch that automatically shuts off the heater if it falls over,
- protective grille to prevent anyone from touching the heating elements, and
- sealed heating elements encased in metal or ceramic.

To use your portable electric space heater safely, follow these guidelines.

- Check what other appliances share the space heater's electric circuit to prevent overloading circuits.
- Avoid using extension cords.
- Inspect the cord on the heater for any cracks or worn spots, and replace the cord or heater if any are found.
- Make sure the area in which you are using the heater has a properly functioning smoke detector.
- Keep combustible objects, such as blankets, furniture, drapes, toys, etc., at least six feet (two meters) away from the heating elements.

Portable Electric Heater

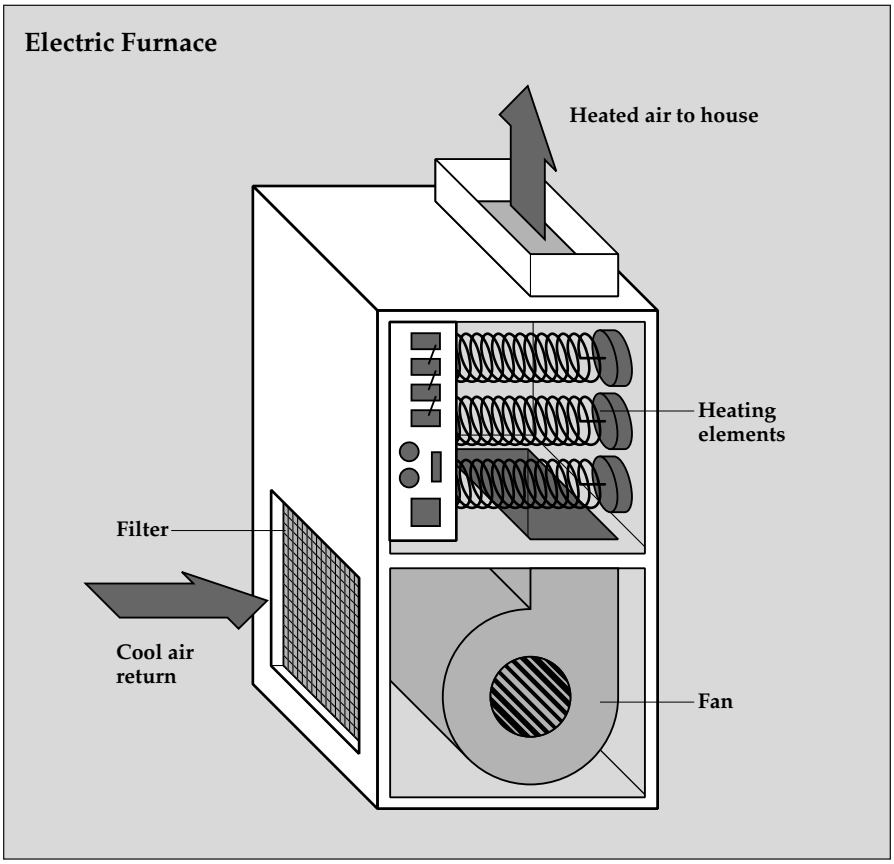


This radiant heater is one of several types of electric space heaters available. These heaters can save you money if you set the central thermostat lower and use these to heat individual rooms.

Electric Furnaces

Electric furnaces can be a more expensive long-term heating option because of their duct heat losses. The home's air is delivered to the furnace through return ducts, and heated air is delivered back to the home through supply ducts. If these ducts run through unheated areas, they lose some of their heat through air leakage as well as heat radiation and convection from the duct's surface.

Blowers (large fans) in electric furnaces move air over a group of three to seven electric resistance coils, called elements, which are each rated at five kilowatts. The furnace's heating elements activate in stages to avoid overloading the home's electrical system. Overheating is prevented by a built-in thermostat called a limit controller. This limit controller may shut the furnace off if the blower fails or if a dirty filter is blocking air flow.



In an electric furnace, a squirrel-cage fan blows air over electric resistance coils and into the main duct, where the warm air then enters your home.

Electric Thermal Storage

Some electric utilities structure their rates in a way similar to telephone companies and charge more for electricity during the day and less at night. They do this in an attempt to reduce their "peak" demand.

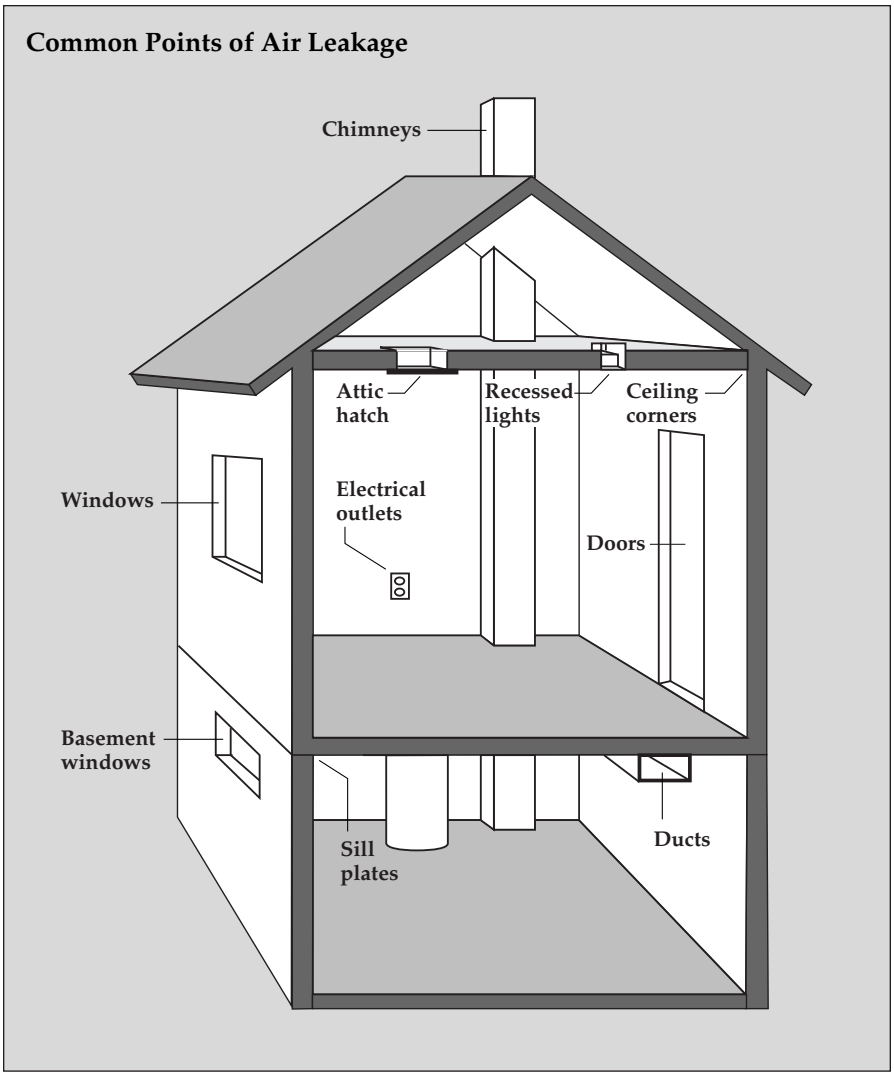
If you are a customer of such a utility, you may be able to benefit from a heating system that stores electric heat during nighttime hours when rates are lower. This is called an electric thermal storage heater, and while it does not save energy, it can save you money because you can take advantage of these lower rates. However, electric thermal storage is a seldom-used type of electric heating.

The most common type of electric thermal storage heater is a resistance heater with elements encased in heat-storing ceramic. Central furnaces incorporating ceramic block are also available, although they are not as common as room heaters. Storing electrically heated hot water in an insulated storage tank is another thermal storage option.

Some storage systems attempt to use the ground underneath homes for thermal storage of heat from electric resistance cables. However, this requires painstaking installation of insulation underneath concrete slabs and all around the heating elements to minimize major heat losses to the earth. Ground storage also makes it difficult for thermostats to control indoor temperatures.

Energy-Saving Measures

No matter what electric heating system you use, there are steps you can take to reduce your energy consumption. These methods include maximizing insulation, perhaps installing quality windows, reducing air leakage, using zone heating, and regularly replacing or cleaning filters in forced-air systems, all of which will make your home more comfortable and efficient and will save you money.



The electrically heated home should be as tight as possible. Here are some common air leakage points that can be sealed with caulk, weatherstripping, and insulation.

An electrically heated home needs to be well sealed against air infiltration yet allow for adequate fresh air intake.

Insulation

To keep heating costs reasonable, electrically heated homes should be very well-insulated. Insulation's ability to slow heat flow is measured by R-value ("R" stands for thermal "resistance"). The higher the R-value, the better the insulation restricts heat flow.

However, just because you have an adequate R-value does not necessarily mean your home is well-insulated. The insulation must be properly installed as well. Gaps and voids in the insulation—even small ones—create air convection or air leakage that markedly reduce rated R-values. For more information on insulation, contact EREC.

Windows

Instead of R-value, windows are usually rated by their heat transfer coefficient, or U-value. The lower the U-value, the better the window's thermal resistance, or resistance to heat loss.

While energy-efficient windows are important in any house, electrically heated homes especially should have windows with U-values of less than 0.40. Advanced window designs incorporate multiple glazing layers, heat-reflective coatings, or gas fillings to reach U-values less than 0.25. Installing storm windows—even over double-pane windows—is often cost effective for homes in cold climates with high electricity costs. (Contact EREC for more information on windows.)

Reducing Air Leakage

Your Home's Envelope

To reduce your heating costs, your home's exterior walls—also known as the "envelope"—need to be as airtight as possible yet still provide healthy indoor air. Methods to achieve an airtight home are now practiced by many building contractors. Air-sealing measures include wrapping the shell of the new house with an air infiltration barrier and installing gaskets and sealants to thoroughly seal joints and penetrations in the building shell. However, these steps are not foolproof. Complicated floor plans, irregular roof lines, protruding windows, cathedral ceilings, fireplaces, or recessed light fixtures can make air sealing during construction difficult, if not impossible. As a result, homes with some or all of these features often have high heating costs due to excessive air leakage.

Your Home's Duct Work

A forced-air furnace's air ducts also influence residential air leakage. Homes with furnaces and ducts sometimes have greater air leakage than homes without ducts, such as radiant-heated or baseboard-heated homes. Heat is frequently

Zone heating can produce energy savings of more than 20% compared to heating every room—occupied and unoccupied—in your house.

lost through leaky or uninsulated ducts. Joints between sections of ducts, between ducts and registers, and between ducts and the furnace can lose as much as 30% of the air being moved by the blower.

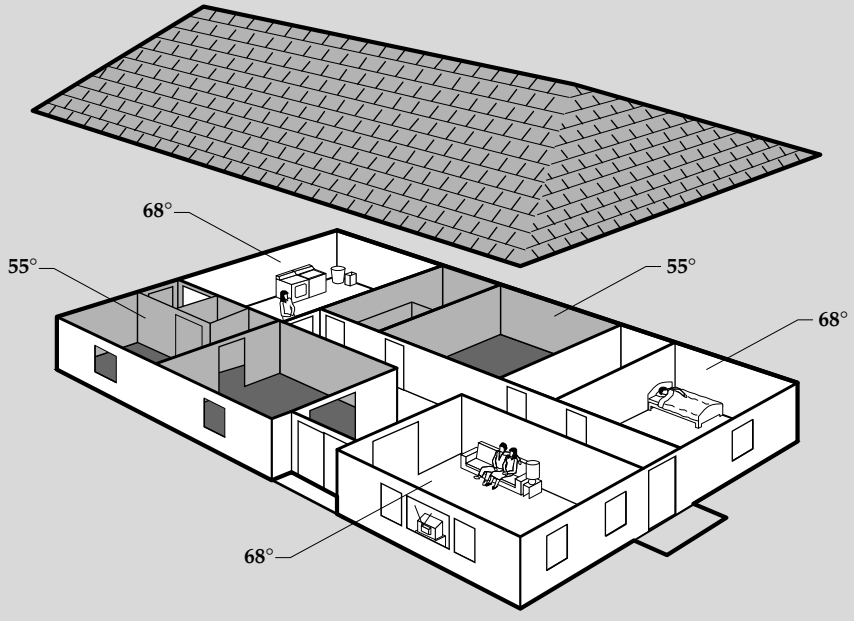
Leaking ductwork can create positive and negative room pressures that often increase air leakage through floors, exterior walls, and ceilings. Reducing or eliminating air leaks will make your home more energy efficient and comfortable.

The importance of airtight ducts has only recently been recognized by the building industry. New ducts need to be sealed with commercial duct mastic as they are assembled. Existing duct systems can be leak-tested and sealed by an experienced professional. Contact EREC for more information on this.

Zone Heating

Zone heating cuts costs by heating the rooms occupied by you or your family while allowing unoccupied sections to remain cooler.

Electric Zone Heating



Zone heating is energy efficient because it heats only those areas of your house in which there are people.

Zone heating can produce energy savings of more than 20% compared to heating both occupied and unoccupied areas of your house. Of course, the amount of savings you will achieve depends on how the portable or built-in zone heaters are combined with your centralized heating system.

One recommended zone heating strategy involves controlling the centralized heating system with an automatic setback thermostat. During the times when everyone is at home and active, the automatic setback thermostat provides a comfortable temperature throughout the house. For the remainder of the day or night, it lowers house temperatures to between 50°F and 60°F (between 10°C and 15.6°C). During these setback times, zone heaters provide additional room heat only as needed.

Furnace Filters

Furnace filters are designed to keep the blower, heat exchanger, and ductwork clean. Your furnace cannot run as efficiently if the filters, blowers, and heating coils are dirty. Plus, it is much easier to change or clean filters than to clean blowers, heating coils, and ductwork.

Filters are composed of either fiberglass wool framed in cardboard, air-permeable foam rubber, or fibrous plastic. They are usually positioned near the blower. Depending on the type of filter used in your system, it is a good idea to replace or clean them monthly during the heating season. Read your furnace's instruction manual for more information.

Indoor Air Quality and Ventilation

Many homes that use zonal electric heating systems (baseboard or radiant heat) have very low air leakage rates. Chimneys and leaky ducts promote air leakage, because they can create pressure differentials within the home. This unintentional ventilation keeps the air indoors moving. However, uncontrolled air leakage is a poor way to keep air fresh in any home—and especially in an electrically heated

home. A controlled mechanical heat recovery ventilation (HRV) system is the preferred way to provide good indoor air quality. Contact EREC (see *Source List*) for more information on HRV systems.

Zone-heated homes with fairly airtight building shells can have moisture and air pollution problems because of very low air leakage along with the lack of a ventilation system. Mechanical ventilation can remove air pollution and moisture. A relatively airtight, electrically heated home should be supplied with fresh air from a controlled mechanical ventilation system. This ventilation system can consist of exhaust fans, a central exhaust air system, an air-to-air heat exchanger with its own ducts, or an outdoor-air inlet into an electric furnace or heat pump.

Thermostats for Electric Heating

Choosing the right thermostat for your electric heating system is crucial to maintaining a comfortable indoor environment and enhancing your home's energy efficiency. Thermostats are classified as *line-voltage* or *low-voltage* thermostats, depending on whether the heater's electric current flows through them. Thermostats are called *built-in* if they are attached to the heater and *remote* if they are mounted on a wall.

Line-Voltage Thermostats

The most simple thermostat is the line-voltage thermostat, which is used for baseboard and radiant electric heat. The electricity it controls flows through it—much like a light switch. Line-voltage thermostats can be either built-in or remote. Built-in, line-voltage thermostats are attached directly to the heater and are subjected to temperature extremes. Therefore, they often do not sense room temperatures accurately. While portable electric heaters must have built-in thermostats, baseboard or radiant heaters provide better room comfort when controlled by remote thermostats. Line-voltage thermostats, installed on interior walls, are more accurate because they measure the temperature of the air of the occupied space rather than the temperature at the heater itself.

Low-Voltage Thermostats

Low-voltage thermostats are used on electric furnaces, heat pumps, and on baseboard and radiant heaters in large rooms for better temperature control. Low-voltage thermostats require a *transformer* to reduce voltage and a *relay* (remote-controlled switch) to turn the heater on and off.

Low-voltage thermostats are always installed in remote locations, rather than being integrated into the heater. They control temperature more precisely than line-voltage thermostats. Low-voltage thermostats are preferred for larger rooms, heated by radiant panels or electric baseboard heaters, because they produce better comfort.

Automatic Setback Thermostats

Automatic setback thermostats combine a clock and a thermostat to control the heater automatically. They are convenient and very effective at saving energy. If your family has a regular schedule of being at home and away, a setback thermostat could save you 5% to 20% of your heating and cooling costs depending on the duration of setback periods and the degrees of temperature setback.

Automatic setback thermostats can be used to control all types of electric heat. For baseboard and radiant heat, line voltage setback thermostats are available. These are either programmed with a clock or they require the user to push a button at regular intervals to avoid the setback temperature (usually 10 or 15 degrees). Contact EREC (see *Source List*) for more information on automatic and programmable thermostats.

Further Information

Many utilities offer grants, loans, or rebates to encourage energy efficiency. Contact your local electric utility for information about residential energy conservation, insulation and weatherization programs, electric thermal storage, or heat pumps.

Source List

For more information about these, and other, energy efficiency topics, contact:

The Energy Efficiency and Renewable Energy Clearinghouse (EREC)
P.O. Box 3048
Merrifield, VA 22116
(800) DOE–EREC (363–3732)
Fax: (703) 893–0400
E-mail: doe.erec@nciinc.com

EREC provides free general technical information to the public on the many topics and technologies pertaining to energy efficiency and renewable energy.

There are many groups that can help you make an informed decision when purchasing an energy efficiency product or system. The following trade associations also offer educational services relating to electric heating, conservation of electricity, and energy efficiency.

American Public Power Association (APPA)
2301 M Street NW
Washington, DC 20037–1484
(202) 467–2900
Fax: (202) 467-2910

APPA is a public utility membership organization that conducts research programs, compiles statistics, and offers education courses for electric utilities and cooperatives.

Building Research Council
University of Illinois at Urbana–Champaign
1 East St. Mary's Road
Champaign, IL 61820
(217) 333-1801
Fax: (217) 244-2204
www.arch.uiuc.edu/research/brc

This organization publishes a variety of fact sheets about home heating and energy conservation.

Edison Electric Institute (EEI)
701 Pennsylvania Avenue NW
Washington, DC 20004–2696
(202) 508–5424
www.eei.org

EEI is the association of the nation's investor-owned electric utility companies and provides information on a variety of electricity topics through its publications catalog.

Electric Power Research Institute (EPRI)
3412 Hillview Avenue
Palo Alto, CA 94304
(650) 855-2000
www.epri.com

EPRI, a research consortia, develops solutions to make the generation, delivery, and use of electricity affordable, efficient, and environmentally sound.

Reading List

***Home Energy* Magazine**
2124 Kittredge Street, #95
Berkeley, CA 94704
(510) 524–5405

This publication provides information on reducing energy consumption.