HOME HEATING BASICS

An Overview of Options

Adapted from the *Consumer Guide to Home Energy Savings*

Dmitry Kutlayev

Space heating is the largest energy expense in most homes, accounting for 35% to 50% of annual energy bills. Upgrading your heating system could reduce your bills significantly. But how do you know what system is right for your home? Here's an introductory look at the options available today.

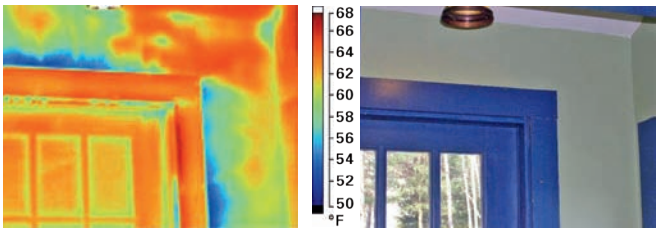
Courtesy www.energyconservatory.com

A blower door test, part of a typical energy audit, can help identify air leaks in your home that reduce the effectiveness of your heating system.

Selecting a System

If you can't seem to stay comfortable or keep your heating bills down, first hire a qualified home performance or heating contractor to help evaluate your home's existing system and determine the best actions to take. It may be that a component of your heating system was improperly installed or needs a tune-up. In many cases, they may find that your heating system isn't the problem, but rather that your home's insulation, windows, weatherproofing, or ducts need help.

Sizing the system. How much heat you need depends on the size of your house and how well it keeps heat in. Never figure out how big a system you need by basing it on the size of the old system. A heat-loss analysis is the only way to properly size a new heating system. (A possible exception exists when replacing steam or hydronic systems: The boiler needs to be sized to the existing radiators you have or plan to add.) A heat-loss analysis should include measurements of wall, ceiling, floor, and window areas and account for insulation levels and weatherization features, including any energy improvements that have been made. Online calculators and free software are available to make this task easier (see Access).



Courtesy www.billcalfee.com

Thermal imaging can help locate areas of heat leakage to address with weather stripping or insulation.

A new heating system should be sized no more than 25% over the peak heating demand. For example, if your home's peak heating demand is calculated to be 60,000 Btu per hour, you should select a heating system with a heating output between 60,000 and 75,000 Btu per hour.

Efficiency recommendations. The efficiency levels you want to look for vary according to the type of system and fuel, as indicated in the "Selecting a Heating System" table on page 54. If you live in a cold climate and your house is well sealed and insulated, it usually makes financial sense to invest in the highest efficiency system available. Your heating contractor will help you determine the financial payback periods of the highest efficiency unit compared to lower efficiency ones.

If your home is still in the design phase, passive solar heating will offer the greatest up-front efficiency and long-term savings. Make sure to orient your home to utilize the energy the sun has to offer and specify appropriate amounts of thermal mass and south-facing glazing, and optimal insulation levels. This design strategy will generally allow you to install a smaller-than-typical backup heating system at a reduced cost and increased lifetime savings.

Common Systems

Forced-air furnace. The majority of North American households depend on a central furnace to provide heat. A furnace works by blowing heated air through ducts that deliver the warm air to rooms throughout the house via air registers. This type of heating system is called a ducted warm-air or forced-air distribution system. The air can be heated by natural gas, propane, fuel oil, electricity, or even biodiesel.

Furnaces and boilers (described below) are rated on their "annual fuel utilization efficiency" (AFUE), which includes start-up, cool-down, and other losses that occur in real operating conditions. The higher the AFUE, the more efficient the furnace or boiler. The AFUE rating for an all-electric furnace or boiler is between 95% and 100%. Units installed outdoors have a lower AFUE because they have greater jacket heat loss. A typical gas- or oil-fired furnace has a hard time keeping valuable heat from escaping up the flue, but "condensing" furnaces are designed to reclaim much of this escaping heat from exhaust gases. High-efficiency oil- and gas-fired systems (85% or greater AFUE) are typically condensing models.

Although it's frequently overlooked, the electricity drawn by a furnace to power its motors and blow air through the house can be considerable—more than 1,200 kilowatt-hours (KWH) per year for some models, adding up to $100 or more to annual electricity costs. This power consumption is not factored into the AFUE ratings, so motor power and efficiency should also be considered when choosing a new furnace.

Boilers are special-purpose water heaters. While furnaces carry heat in warm air, boiler systems distribute the heat in hot water or steam, which gives up heat as it passes through radiators or radiant floor heaters in rooms throughout the house. The cooled water then returns to the boiler to be reheated. In a hot-water system, also called a "hydronic" system, the water is typically heated to about 180°F (or less in a high efficiency system). In steam boilers, which are much less common in modern homes, the water is boiled and steam carries heat through the house, condensing to water in the radiators as it cools. Instead of a fan and duct system, a hot-water boiler uses a pump to circulate hot water through pipes to radiators.

COMMON SYSTEM TYPES

Courtesy www.rheem.com

A forced-air furnace uses natural gas, propane, oil, or electricity to heat air and an electric blower to circulate it throughout your home.

Courtesy www.htproducts.com

A boiler works like a forced-air furnace, but heats and circulates water, instead of air, to radiators or hydronic floor loops.

A heat pump removes heat from the outside air or the ground using phase-change materials. They can work in reverse to provide cooling in hot weather.

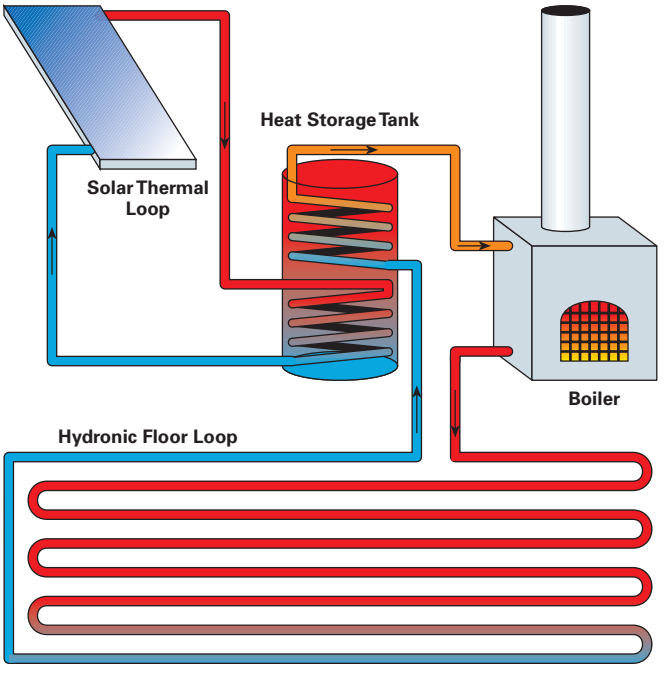
Courtesy www.sunplans.com

Designing new homes or additions using passive solar design strategies can reduce heating costs and increase comfort.

Oil or natural gas is commonly used to heat water in boilers; as with gas- and oil-fired furnaces, boilers can be designed to condense water vapor in the exhaust pipe to reclaim some escaping heat.

Radiant floor heating generally refers to systems that warm the floor, either with electric elements or, more commonly, by circulating warm water in tubing in or under the floor. This warms the room gently, without the noise of blowers and air rushing through ducts. These systems are fairly easy to configure in separate zones, with controls for heating individual rooms. Hydronic (liquid-based) systems are the most popular and cost-effective radiant heating systems for cold climates. For added efficiency, the circulating water can be heated by solar hot water collectors, with the boiler providing a temperature boost, if needed.

HYDRONIC HEATING WITH SOLAR & BOILER



Note: Pumps and other components not shown.

Electric radiant floors typically consist of electric cables built into the floor. Mats of electrically conductive plastic are also available, and are attached to the subfloor, below a floor covering (usually ceramic tile). Because of the relatively high cost of electricity, electric radiant floors are usually only cost effective in small areas like bathrooms, or if they include thermal mass, such as a thick concrete floor, and your electric utility offers time-of-use rates, which allow you to "charge" the concrete floor with heat during less expensive, off-peak hours. If the floor's thermal mass is large enough, and your home is well insulated, the heat stored in the thermal slab will keep the house comfortable for several hours without any further electrical input.

Heat pumps are just two-way air conditioners. During summer, an air conditioner works by moving heat from

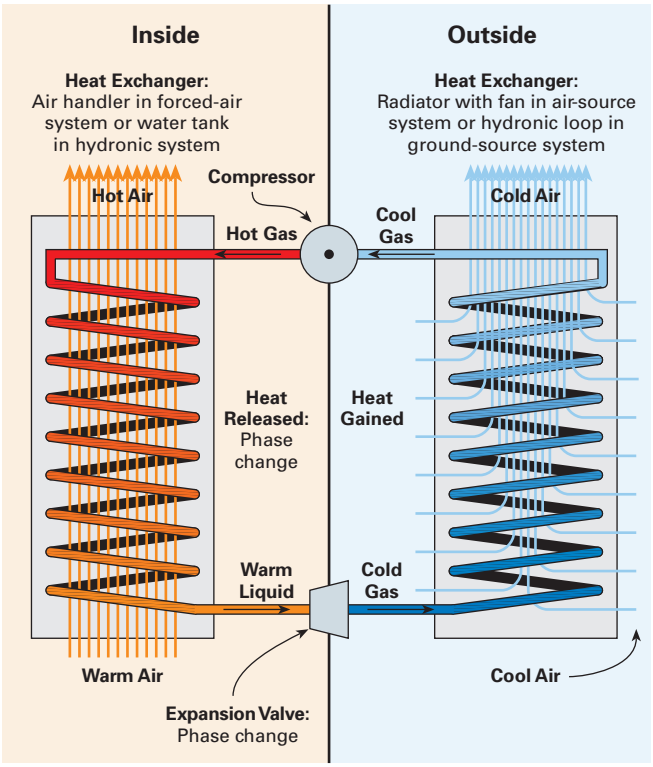
Courtesy www.gimmeshelteronline.com

These hydronic heating loops are awaiting the pour that will embed them in concrete slabs. They can also be installed between floor joists or in specially designed subflooring panels.

Courtesy www.warmlyyours.com

Electric radiant mats can be installed between the subfloor and many types of floor surfaces.

AIR-SOURCE & GROUND- SOURCE HEAT PUMPS



Note: System is reversible to cool house in summer.

the relatively cool indoors to the relatively warm outside. In winter, a heat pump reverses this trick, scavenging heat from the outdoors and discharging that heat inside the house. Almost all heat pumps use forced warm-air delivery systems to move heated air throughout the house.

Air-source heat pumps use the outside air as the heat source in winter and heat sink in summer and are installed much like a central air conditioner. Heat pumps are far more energy efficient than electric furnaces, and they can be used for both heating and air conditioning. But before deciding to replace your present system with a heat pump, you should carefully look into whether it makes sense in your climate. Because air-source heat pumps rely on the outside air as the heat source in the wintertime, the colder that air, the worse the energy performance. Air-source heat pumps make more sense in warmer climates, where summer cooling loads are considerable. Cold-climate air-source heat pumps, which are specially designed for optimal winter use, are currently offered by some manufacturers, and are in field trials by several utilities.

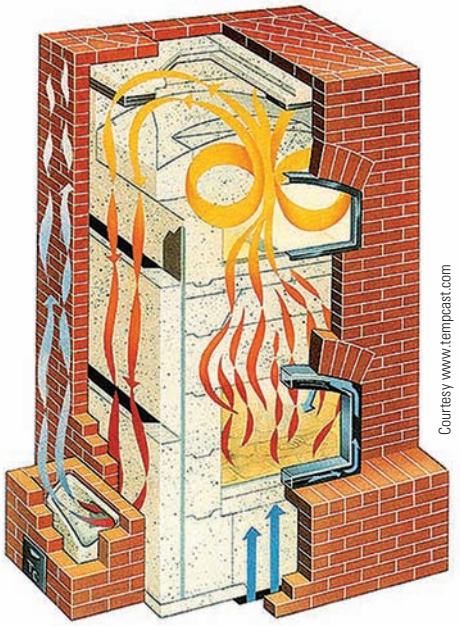
Because underground temperatures are nearly constant year-round—warmer than the outside air during the winter and cooler than the outside air during the summer—a ground-source heat pump (also called geothermal, GeoExchange, or GX) can be much more efficient than an air-source unit and appropriate for both warm and cold climates. These heat pumps require that a pipe loop (typically, polyethylene) be buried in the ground, usually in long, shallow (3- to 6-foot-deep) trenches or in one or more vertical boreholes, from 100 to 400 feet deep. Alternatively, some systems draw in groundwater and pass it through the heat exchanger instead of using a refrigerant. The groundwater is then returned to the aquifer.

According to the U.S. Department of Energy's Energy Efficiency and Renewable Energy Information Center (EERE), even though the installation price of a geothermal system can be several times that of an air-source system of the same heating and cooling capacity, the additional costs are made up in energy savings in five to ten years. Inside components should last at least 25 years and the ground loop, more than 50 years.

Wood and pellet-burning heaters. Wood heating can make economic sense in rural areas if you enjoy stacking wood and stoking the stove or furnace. But for fuel efficiency and cost effectiveness, it is important to properly size the heater to the space, otherwise your heating plans will just go up in smoke—literally. All wood heaters sold today should bear a U.S. Environmental Protection Agency certification sticker, which specifies that they meet emissions standards. Higher-efficiency heaters (typically 63% to 78% efficiency) produce fewer emissions and are often safer, since complete combustion helps to prevent a buildup of flammable chimney deposits.

Pellet stoves, which use small pellets made of sawdust and wood chips for fuel, have lower point-of-use emissions than wood heaters and offer users greater convenience, temperature control, and indoor air quality, along with combustion efficiencies between 78% and 85%. One drawback is that they require electricity to run fans, controls, and pellet feeders. Under normal usage, they consume about 100 KWH of electricity per month.

MASONRY FIREPLACE



Courtesy www.tempcast.com

Quick, hot fires coupled with thermal mass to absorb this heat lend to the efficiency of a masonry heater.

SELECTING A HEATING SYSTEM

Fuel	Current System	Replacement Options	Recommendations
Gas	Forced air	Condensing furnace	AFUE ≥ 90 (Energy Star)
			High-efficiency furnace fan
			Sealed-combustion preferable
			May require new flue lining for water heater or new power vent water heater
		Non-condensing furnace	Mild climates (deep South, Pacific NW) only. High-efficiency furnace fan
		Switch to hydronic system	Expense may preclude unless part of large-scale renovation
			Better option where mild summers make central air conditioning unnecessary
	Hydronic	Non-condensing boiler	Mild climates (deep South, Pacific NW) only
		Condensing boiler	AFUE ≥ 85 (Energy Star)
			Sealed-combustion preferable
			Insist on outdoor reset or equivalent controls
			Consider indirect water heater tank
		Switch to forced air	Consider this option if you have a single-pipe steam system and central air conditioning
	Combination space/ water heater		Explore this if you also are looking to replace your water heater
Oil	Forced air	Furnace	AFUE ≥ 83 (Energy Star)
	Hydronic	Boiler	AFUE ≥ 85 (Energy Star)
			Sealed-combustion preferable
			Insist on outdoor reset or equivalent controls
			Consider indirect water heater tank
	Switch to gas	(See "Gas" options)	Switching to natural gas may save you money and allow for a more efficient system
Electricity	Resistance system: furnace or baseboard	Switch to heat pump	Cheaper option especially if you have forced air and are replacing a central air conditioner
		Switch to gas	Consider if you have a gas line and a central air conditioner in good condition
		Supplemental direct heat	Not recommended as replacement option
			Only use in rooms that are remote from the central system
	Heat pump	High-efficiency air-source heat pump	Energy Star-rated or better; quality installation is important
		Ground-source heat pump	Energy Star-rated or better; quality installation is important
			Specify integrated water heating

Adapted from the *Consumer Guide to Home Energy Savings*, 9th edition

Although gas (and most wood) fireplaces provide a warm glow, they are not an efficient heat source. Fireplace-heated homes generally lose more heat than they provide, because heated air is drawn through the unit and must be replaced by cold outside air. However, if the fireplace has a tight-sealing glass door, its own source of outside air for combustion, and a good chimney damper, it can provide some useful heat.

According to the EERE, masonry heaters produce more heat and less pollution than any other wood- or pellet-burning heater, reaching combustion efficiencies of 90%. Masonry heaters include a firebox, a large masonry mass (such as bricks), and long twisting flue channels that run through the mass. A small, hot fire built once or twice a day releases heated gases into the flue tunnels that, in turn, heat the masonry. This heat slowly radiates outward into the home.

Renewable Fuel?

Burning natural gas, oil, propane, cordwood, or pellets in your home with a high-efficiency furnace or boiler can be a very efficient way to deliver heat to your home. Of these, natural gas has the fewest direct emissions. Some fuel-oil furnaces or boilers can also burn biodiesel—a more sustainable and low-pollution solution. Be sure to check with your system's manufacturer first.

Electric resistance converts electricity directly into heat, which means on-site efficiency for electric heaters is very high and there is no point-of-use pollution emitted. But when the inefficiency of electricity generation by the power company and transmission losses are taken into account, it is actually pretty inefficient to heat with electric resistance. Roughly one-third of the heating value of the fuel burned in a power plant is delivered

HEATING SMALL SPACES

Small space heaters are typically used when the main heating system is inadequate or when central heating is too costly to install or operate.

Solar air collectors can be installed on a roof or an exterior (south-facing) wall for heating one or more rooms. Factory-built collectors for on-site installation are available, and do-it-yourselfers may choose to build and install their own collector.

Gas-fired space heaters include wall-mounted, freestanding, and floor furnaces, and are most useful for warming a single room or contiguous areas. Better models use "sealed combustion air" systems, with pipes installed through the wall to both provide combustion air and carry off the combustion products. A warning: Ventless gas heaters can expose occupants to combustion by-productss and oxygen depletion, as can stand-alone kerosene, propane, and oil heaters. Because of these hazards, at least five states prohibit vent-free heaters in homes, and many individual cities have banned them as well.

Electric space heaters. Portable (plug-in) electric heaters and electric baseboard units convert electricity directly into heat. Generally, these systems have low or no installation costs. With baseboard heaters, individual room thermostats can be installed so you can turn down the heat in rooms that aren't being used. Operating costs, as for all resistive heaters, are generally very high.

Shawn Schreiner

Solar thermal collectors can efficiently heat your home, and large PV systems can offset some or all of the energy used for electric heating.

as useful heat in your house—the remaining two-thirds are lost to generation and transmission inefficiencies. On the other hand, electricity is used to run heat pumps, which have the benefit of producing more energy than the electricity they consume and can balance out the efficiency losses at the power plant.

In many cases, surplus electricity from an off-grid solar-, wind-, or hydro-electric system can be routed to a heating load, such as an air or water heating element. This can be one effective application of heating with renewably produced electricity. If your home has a large enough grid-tied RE-electric system, the electricity produced may be enough to offset a significant portion of the energy consumed by an electric heating system. If avoiding utility-powered electric heating is not an option, consider purchasing enough "green tags" or green energy credits from your utility to offset your electrical heating energy use.

Of course, the cleanest fuel for heating (and possibly cooling) your home is solar energy, which produces no on-site emissions at all. New homes in cold or moderate climates should be designed to take advantage of passive solar heating. Active solar heating systems can be used in new or existing homes and are compatible with many conventional heating systems. Homeowners can use either solar air heating collectors for preheating of ventilation air or solar water heating collectors to supplement water heating systems. Solar energy can also be used to boost the performance of heat pumps, and an absorption heat pump will allow you to power an air conditioning system with solar energy.

Access

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Online home heat loss calculator • www.builditsolar.com/References/Calculators/HeatLoss/HeatLoss.htm

Info on efficient furnaces, boilers, and heat pumps • www.energystar.gov

List of clean-burning wood heaters & fireplaces • www.epa.gov/woodstoves