Types of Heating Systems

Gas heating systems can be fueled by either natural gas or propane with simple modifications accounting for the different characteristics of each. We refer to both fuels as simply "gas." The most common types of systems include forced air, hot water, steam, and localized space heating.

Forced Air

Forced-air gas furnaces heat the majority of American single-family homes. Their efficiencies vary, but some new furnaces are among the most efficient heating systems available.

Forced air systems draw cool air from the home and supply warm filtered air to each room. Most forced air systems have both a supply and return register serving every room. However, many forced-air systems have only one or two return registers.

Problems can occur when interior doors are shut. Supply registers will pressurize some rooms, while areas equipped with return registers are depressurized. This pressure imbalance increases the likelihood of air leakage and heat loss throughout the building shell. Transfer grilles, jump ducts, or door undercuts may be used to mitigate these problems, especially when a central return is used.

Many forced air duct systems also have significant air leaks. Duct leakage allows substantial heat loss in cases where ducts are located in unconditioned crawl spaces, attics, or attached garages.

Hot Water

Hot-water or hydronic heating systems circulate boiler-heated water through radiators, baseboard convectors, radiant floors, or fan-forced coils. Hot-water systems are slightly more expensive than forced-air systems but their radiant heat offers some comfort advantages. Many older hot-water systems, which have performed reliably for decades, continue to provide comfort very efficiently.

Hot-water systems are most popular in cold-climate new construction. Hot air systems are preferable in mild climates since their duct systems can be used to deliver air conditioning as well.

Steam

Steam systems require higher temperatures, which make them inherently less efficient than forced air or hot water.

The first central heating systems for buildings used steam distribution because steam moves itself through piping without the use of pumps. Non-insulated steam pipes often deliver unwanted heat in unfinished areas. Therefore, pipe insulation in these areas is usually very cost effective. Care should be used to install fiberglass pipe insulation that can withstand the high temperatures of these delivery pipes.

Hot-water systems are most popular in cold-climate new construction. Hot air systems are preferable in mild climates since their duct systems can be used to deliver air conditioning as well.

Localized Space Heating

Supplemental or localized heating systems provide heat to a specific portion of the home. They have an efficiency advantage over central systems because they have no pipe or duct system where heat can be lost.

Space heaters—permanently mounted in the wall, freestanding, or small portable heaters—can boost the temperature of hard-to-heat rooms, new additions, or rooms used by individuals who are sensitive to cold, especially elderly persons. A space heater may allow you to set the thermostat for the central system at a more economical level or to heat a small portion of the home in moderate weather without using the larger central system.

Modern, wall-mounted, gas space heaters incorporate several features that make them safer and more efficient than most older ones. Many are vented through the wall, and they may have combustion air ducted directly to the burner. Electric space heaters, such as baseboard units, are usually more expensive to operate than gas space heaters, though their lower initial cost and ease of operation make them attractive in some cases.

Maintenance, Service and Cleaning
Regular maintenance, service, and cleaning will keep your heat system operating at peak efficiency. Some of these tasks you can do yourself. Other more technical or dangerous tasks are best left to qualified technicians.

Homeowner Maintenance

Forced-air Systems

- Change or clean filters every month, or whenever they look dirty, during the heating season.
- Keep heat registers clean and unobstructed.
- Adjust the room registers to control the amount of heated air entering the room. Close them just enough to slow the airflow as needed: closing them completely saves little energy.

Hot-water Systems

- Keep radiators and baseboard units clean; dirt and dust will reduce heat output. Remove radiator covers, if used, to allow maximum airflow.
- If your home has traditional cast-iron radiators, add reflectors between the radiators and the wall to increase the amount of heat directed into the room.
- Arrange furniture and draperies so they do not block radiators or baseboard units.
- Bleed air from hot-water radiators once or twice each heating season. Close the valve after all the air is discharged.

Professional Service

All Systems

- Check the condition of your vent connection pipe and chimney. Parts of the venting system may have deteriorated over time and, without proper repair, may cause problems. Chimney problems can be expensive to repair, but may be justified unless you're installing new heating equipment that won't use the existing chimney.
- Check the physical integrity of the heat exchanger. Leaky boiler heat exchangers leak water and are easy to spot. Furnace heat exchangers mix combustion gases with house air when they leak—an important safety reason to have them inspected.
- Adjust the controls on the boiler or furnace to provide optimum water and air temperature setting for both efficiency and comfort.
- If you're considering replacing or retrofitting your existing heating system, have the technician perform a combustion-efficiency test.
- You may want to discuss your options for repair, retrofit, and replacement. Be sure to discuss the costs and the benefits of each option.

Forced-air Systems

- Check the combustion chamber for cracks.
- Test for carbon monoxide (CO). Remedy cause of CO if found.
- Adjust blower control and supply-air temperature.
- Clean and oil the blower.
- Remove dirt, soot, or corrosion from the furnace or boiler.
- Check fuel input and flame characteristics, and adjust if necessary.
- Seal connections between the furnace and main ducts.

Hot-water Systems

- Test pressure-relief valve.
- Test high-limit control.
- Inspect pressure tank, which should be filled with air, to verify that it's not filled with water.
- Clean the heat exchanger.

Steam Systems

- Check the steam vents and traps. These allow steam to travel quickly to the radiators without escaping into the home.
- Drain some water from the boiler to remove sediments. This improves the heat exchange efficiency.
- Test low-water cutoff safety control and high-limit safety control.
- Drain the float chamber to remove sediments. This prevents the low-water cutoff control from sediment clogs.
- Analyze boiler water and add chemicals as needed to control deposits and corrosion.
- Clean the heat exchanger.

Cleaning the Combustion Systems

Gas furnaces and boilers might operate for years without maintenance if properly installed in a perfectly clean environment. But many heating systems are installed in dirty basements, crawl spaces, and garages. Over time the heat exchanger, burners, and burner ports will accumulate dust, lint, soot, or rust that affects efficiency.

Tune-ups should include brushing and vacuuming the combustion system. Service technicians should also check for soot or corrosion that can be caused by incomplete combustion or inadequate venting of combustion gases.

Weatherize First

Before you assume that your heating system is the reason for a cold house or high energy bills, make sure your home is adequately weatherized. A well-insulated and airtight building will make any heating system shine, while a poorly insulated and drafty building may tarnish the performance of the most energy-efficient heating system.

Weatherization involves two main tasks: insulation and air-tightening. Caulking and weather stripping your windows and doors will help prevent air leakage. If you aren't sure what other weatherization improvements your home needs, like how much insulation, have a technician conduct an energy audit.

Contact your state energy office or utility company. Either one should be able to advise you on how to obtain an audit. Some states and utilities perform energy audits, loan money for weatherization projects, or give rebates for the purchase of insulation and other energy-saving products.

Retrofitting Existing Heating Systems

Retrofitting means adding to or changing an existing heating system. Some retrofitting options that can improve a system's energy efficiency include installing programmable thermostats, vent dampers, intermittent ignition devices, additional ductwork, zone control for hot-water systems, and converting steam systems into hot-water systems.

Programmable thermostats

The simplest and most immediate way to save energy is to install a programmable thermostat. A programmable thermostat will automatically lower the temperature while you're asleep at night and whenever your home is unoccupied. It can adjust the temperature several times during the day with separate settings available on weekends.

The energy savings from a programmable thermostat will depend on how much it reduces the room temperature and for how long. In an average house, you might save 1 to 2 percent of your annual heating cost for each degree of setback maintained over an 8-hour period.

Forced-air systems have the quickest response times. This makes them a good choice for use with programmable thermostats. Heating-and-cooling programmable thermostats are an excellent choice for homes with air conditioning because they can increase the set point when the home is unoccupied.

If you choose to install a programmable thermostat, it is very important to check settings frequently and reprogram it when necessary, especially when the house will be unoccupied for an extended period of time.

Vent Dampers

The most common retrofit is the addition of a vent damper. A vent damper prevents chimney losses by closing off a boiler's vent when the boiler isn't firing. Steam boilers benefit from vent dampers more than hot-water boilers, and bigger boilers benefit more than smaller ones. Vent dampers, however, may not be cost effective with properly sized, newer furnace models.

Intermittent Ignition Devices

Older furnaces and boilers are sometimes retrofitted with intermittent ignition devices that eliminate the continuous pilot light. Although these intermittent ignition devices can save you some in fuel costs, they are not always cost effective when installed on aging equipment. If it's possible to turn off your furnace's pilot in the spring and to turn it on again in the fall, you can save the same amount of money as you would using one of these devices. However, you won't save energy turning off the pilot intermittently yourself during the heating season.

Ductwork—Forced Air

It's common to upgrade forced-air duct systems by adding additional return ducts and replacing damaged fiberglass duct board and fiberglass-and-plastic flex ducts. The savings can be substantial if the existing ductwork leaks or is installed in unheated areas.

Additional return ducts may be helpful if the central return can be isolated from the rest of the house by closing off all the internal doors, and using door undercuts or transfer grilles.

Zone Control And Radiators—Hot Water

Hot-water distribution systems can be retrofitted to provide separate zone control for different areas of large homes. The old large cast-iron radiators can be replaced with space-conserving baseboard radiators, wall-hung radiators, or fan coils.

Converting Steam System To Hot Water

Steam systems can be converted to hot-water systems, sometimes salvaging the boiler, piping, or radiators. However, it might be more cost effective to replace the entire steam boiler with a new compact, hot-water boiler.

Replacing Heating Systems

Installing a newer, more efficient heating system can provide good energy savings in many situations. However, a solid understanding of efficiency is necessary to make informed purchase decisions.

Annual Fuel Utilization Efficiency

The Federal Trade Commission requires new furnaces or boilers to display their Annual Fuel Utilization Efficiency (AFUE) so consumers can compare heating efficiencies of various models.

AFUE is the ratio of heat output of the furnace or boiler compared to the total energy consumed by a furnace or boiler. An AFUE of 90 percent means that 90 percent of the energy in the fuel becomes heat for the home and the other 10 percent escapes up the chimney and elsewhere. AFUE doesn't include the heat losses of the duct system or piping, which can be as much as 35 percent of the energy for output of the furnace when ducts are located in the attic.

Existing, older furnaces fall between 68 and 72 percent AFUE. Existing, older boilers test a little higher at 72 to 76 percent AFUE. Since 1992, furnaces are required to have greater than 78 percent AFUE, and boilers must have greater than 80 percent AFUE.

System Equipment Efficiency

You can identify and compare a system's efficiency by not only its AFUE but also by its equipment features.

Conventional, Older Heating Systems

- Natural draft that creates a flow of combustion gases
- Continuous pilot light
- Heavy heat exchanger
- 68-to-72 percent AFUE

Mid-Efficiency Heating Systems

- Exhaust fan controls the flow of combustion air and combustion gases more precisely
- Electronic ignition (no pilot light)
- Compact size and lighter weight to reduce cycling losses
- Small-diameter flue pipe
- 80-to-83 percent AFUE

High-Efficiency Heating Systems

- Condensing flue gases in a second heat exchanger for extra efficiency
- Sealed combustion to protect the heat exchangers from indoor chemicals and to isolate the combustion process from indoor air (Condensing furnaces may also be equipped with a plastic pipe that brings air directly to the burner from the outdoors. Combustion gases are generally exhausted outside laterally via a pipe installed through a wall.)
- 90-to-97 percent AFUE

You'll also want to compare the warranties of each furnace or boiler under consideration.

Estimating Fuel-Cost Savings And Payback

If you know the AFUEs of the systems you want to compare, you can estimate the annual savings from heating system replacements by using Table 1 below. For instance, if you have a conventional, older system with a pilot light and no vent damper installed, it will probably have an AFUE of about 60 percent.
Table 1. Annual Estimated Savings for Every $100 of Fuel Costs by Increasing Your Heating Equipment Efficiency*

Existing System AFUE New/Upgraded System AFUE

	55%	60%	65%	70%	75%	80%	85%	90%	95%
55%	$9.09	$16.76	$23.07	$28.57	$33.33	$37.50	$41.24	$44.24	$47.36
60%	----	$8.33	$15.38	$21.42	$26.66	$31.20	$35.29	$38.88	$42.10
65%	----	----	$7.69	$14.28	$20.00	$25.00	$29.41	$33.33	$37.80
70%	----	----	----	$7.14	$13.33	$19.75	$23.52	$27.77	$31.57
75%	----	----	----	----	$6.66	$12.50	$17.64	$22.22	$26.32
80%	----	----	----	----	----	$6.50	$11.76	$16.66	$21.10
85%	----	----	----	----	----	----	$5.88	$11.11	$15.80
90%	----	----	----	----	----	----	----	$5.55	$10.50
	----	----	----	----	----	----	----	----	$5.30

*Assuming the same heat output

To estimate the amount you're spending on gas for heating, you can take your gas bills from the last three years, add them up, and then divide by three to get an average yearly cost. If you use gas for purposes other than space heating, like cooking or water heating, you have to account for this by subtracting the cost of the gas billed for these uses as follows:

1. Add up your gas bills for the four warmest months when heating is not needed.
2. Multiply the result by three to get an estimate of annual nonheating gas costs.
3. Subtract the result from your average yearly cost to get the space-heating cost.

If you want to estimate the annual return on investment and the number of years required to repay your investment, you can use the following simplified formulas:

- Annual savings ÷ initial investment = Annual return
  Example: $250 ÷ $1500 = 0.17 or 17% annual return on investment

- Initial investment ÷ annual savings = Years to Pay Back
  Example: $1500 ÷ $250 = 6 years

To be cost-effective, the payback period should be less than 10 years or so.

Installation Considerations

If you choose to replace your heating system, your research will help you in choosing and negotiating with heating contractors. Don't assume that most heating contractors are the same or that most will do a good job. You may get a variety of bid prices and specifications. And the bids may or may not include some very important tasks. Ask the contractors bidding on your heating system to include the following tasks:

- Calculate the heat load of your home, and size the heating system correctly. Newly installed heating systems are often twice or more the required size.

- Repair or replace existing chimneys as needed. Many existing chimneys are too large for a modern energy-efficient furnace or boiler that is sized to fit the smaller needs of a more energy-efficient home. Many older chimneys are unlined or the liner is deteriorated.

- Seal existing ductwork, if necessary, during furnace replacement. Existing ducts are often leaky, and this leakage is an energy problem if the ducts are located in crawl spaces, attics, or attached garages. All duct joints, located in these unheated areas, should be sealed with duct mastic-a sticky substance superior to tape. Duct tape often fails, and loose duct tape should be replaced by mastic.

- Install supply-duct insulation in crawl spaces, attics, or attached garages during furnace retrofits.

- Install supply-pipe insulation in crawl spaces, attics, or attached garages during boiler retrofits.

- Consider upgrading boiler supply piping strategies. There are many modern ways to run piping for a boiler that offer advantages to older piping systems. For example, a new piping system could divide the system into zones, each controlled by its own thermostat. Or zones could deliver different water temperatures, depending on the type of heat emitters used (radiators, fan coils, radiant floors).

Ensure proper installation by checking that the above tasks are completed before issuing final payment.

If you select the lowest bidding contractor without researching your options, you could get a poor installation that might not provide the energy savings and comfort improvement you were expecting. New heating-system installations are often underbid by 10 to 30 percent, compared to high quality installations. Choose the best contractor based on quality of installation and reputation. And always check references.

Don't forget to establish a maintenance schedule for the new furnace or boiler, and stick to it.

Indoor Air Quality

Any time you maintain, retrofit, or replace a gas heating system you also need to be concerned with air quality. Combustion air is needed by all gas heating systems to support the combustion process. This air is provided in some homes by unintentional air leaks, or by air ducts that connect to the outdoors. The combustion process creates several byproducts that are potentially hazardous to human health and can cause deterioration in your home. You can protect yourself from these hazards, as well as maintain energy efficiency, by ensuring that your chimney system functions properly and that your gas heating system is properly ventilated. In some cases, installing a sealed-combustion furnace or boiler can help too.

Chimneys

Properly functioning chimney systems will carry combustion byproducts out of the home. Therefore, chimney problems put you at risk of having these byproducts, such as carbon monoxide, spill into your home.

Most older gas furnaces and boilers have naturally drafting chimneys. The combustion gases exit the home through the chimney using only their buoyancy combined with the chimney's height. Naturally drafting chimneys often have problems exhausting the combustion gases because of chimney blockage, wind or pressures inside the home that overcome the buoyancy of the gases.

Atmospheric, open-combustion furnaces and boilers, as well as fan-assisted furnaces and boilers, should be vented into masonry chimneys, metal double-wall chimneys, or another type of manufactured chimney. Masonry chimneys should have a fireclay, masonry liner or a retrofitted metal flue liner.

Many older chimneys have deteriorated liners or no liners at all and must be relined during furnace or boiler replacement. A chimney should be relined when any of the following changes are made to the combustion heating system:

- When you replace an older furnace or boiler with a newer one that has an AFUE of 80 percent or more. These mid-efficiency appliances have a greater risk of depositing acidic condensation droplets in chimneys, and the chimneys must be prepared to handle this corrosive threat. The new chimney liner should be sized to accommodate both the new heating appliance and the combustion water heater by the installer.

- When you replace an older furnace or boiler with a new 90+ AFUE appliance or a heat pump. In this case, the heating appliance will no longer vent into the old chimney, and the combustion water heater will now vent through an oversized chimney. This oversized chimney can lead to condensation and inadequate draft. The new chimney liner should be sized for the water heater alone, or the water heater in some cases can be vented directly through the wall.

Ventilation

Some fan-assisted, noncondensing furnaces and boilers, installed between 1987 and 1993, may be vented horizontally through high-temperature plastic vent pipe (not PVC pipe, which is safely used in condensing furnaces). This type of venting has been recalled and should be replaced by stainless steel vent pipe. If horizontal venting was used, an additional draft-inducing fan may be needed near the vent outlet to create adequate draft. Floor furnaces may have special venting problems because their vent connector exits the furnace close to the floor and may travel 10 to 30 feet before reaching a chimney. Check to see if this type of venting or the floor furnace itself needs replacement. If you smell gases, you have a venting problem that could affect your health. Contact your local utility or heating contractor to have this venting problem repaired immediately.

Sealed-combustion Appliances

Some older gas heating systems rely exclusively upon room air and air leaks for combustion air, while some modern sealed-combustion heating systems have dedicated outdoor air supplies directly to the burner.

Sealed combustion furnaces, boilers, and water heaters draw combustion air from outdoors and vent combustion byproducts to the outdoors. Sealed combustion appliances aren't affected by house pressures and are safer than the more common open-combustion appliances, which include most 80+ AFUE furnaces and boilers.

Homes, even new ones, vary in their airtightness quite a bit—some are very tight and some are very leaky. When a home is very airtight, the combustion appliances may malfunction due to a lack of air. The most common malfunctions are combustion-gas spillage and carbon monoxide formation. For this reason, sealed-combustion appliances are the best option for homes that are airtight or depressurized by an exhaust ventilation system. However, any newer furnace should have an induced draft fan that forces flue gases into the vent, unlike older furnaces that have draft diverters, which can allow spillage of flue gases into the home when backdraft conditions are present.

Summary: Simple Steps to Reduce Heating Costs

- Weatherize your home. Insulation and air-sealing improvements to the shell of your home will always improve your comfort, regardless of the size and type of heating system installed. Weatherization may also allow the installation of a smaller, more economical heating system.

- Use a programmable thermostat. This simple, inexpensive device may provide better savings than any other efficiency measure.

- Maintain your system periodically to yield immediate energy savings, improved comfort, and a longer trouble-free service for any system. This includes duct repair and replacement.

- Hire a professional technician to service your heating equipment. Qualified technicians can often identify safety and efficiency issues that aren't immediately apparent. A professional can also teach you about the operation of your heating system and the role you can play in performing minor service tasks.