Is Your Heating System an Energy Beast?

BY DAVE YATES

Here's how to spot the signs and boost the efficiency of your furnace, boiler, or heat pump

The economy is down, fuel costs are up, and chances are that your heating budget is already busted. You need to do something—but what? Only a few of us are ready to invest in geothermal or solar. The rest of us need to find the answer in the heating system we already have.

For 70% of U.S. households, that system consists of a furnace that forces hot air through ducts; for 17%, it's a heat pump; and for 11%, it's a boiler that heats with water or steam radiators. The remaining 2% of homes use wood, coal, geothermal, solar, or other heating methods. When it comes to fuel, 58% of us use gas (either natural or propane), about 35% use electricity, and almost 7% use fuel oil.

Your home might not have the most efficient heating system available, but there's good news: You can tune up your current system so that it performs better, keeps you more comfortable, and doesn't put as big of a dent in your wallet. The following Q&A can help. Although the topics might seem simple, they're useful in diagnosing deficiencies. In fact, I usually end up fielding a lot of these questions from homeowners based on their observations of how their heating system is or isn't working. Once you know where your system is falling down, it's possible to boost it (and its efficiency) back up.

Dave Yates owns and operates F.W. Behler Inc., a mechanical-contracting firm in York, Pa. Technical drawings by John Hartman; illustrations by Jackie Rogers.

Q ***I hear a whistling noise around the blower compartment of my furnace. What is causing the noise? Should I be concerned?***

A **You're hearing air leakage.** All air handlers (any device with a blower, including furnaces, heat pumps, and central air) have two ducts: one for supply, the other for return. I often find considerable air leakage at both connection points. If the blower is located in an unconditioned location (attic, crawlspace, or basement), it is bleeding out heat, or Btu, on the supply side while pulling in unconditioned air that must be warmed (or cooled and dehumidified) on the return side. This energy loss can add 10% or more to your heating and cooling bills.

You can fix these leaks by sealing the connection with sealant and/or top-grade mastic tape rated to withstand the area's exposure. While you're at it, check the air handler's access door, another frequent source of air leaks. Because the access door must be opened to service the equipment, you want to use only tape or magnetic strips to seal gaps. Other spots to seal include filter slots and openings for wiring. Last but not least, the accessible ductwork should be examined for leaks. Seal them with high-quality tape, mastic, or sealant that's compatible with the duct material and with exposure to surrounding air temperatures.

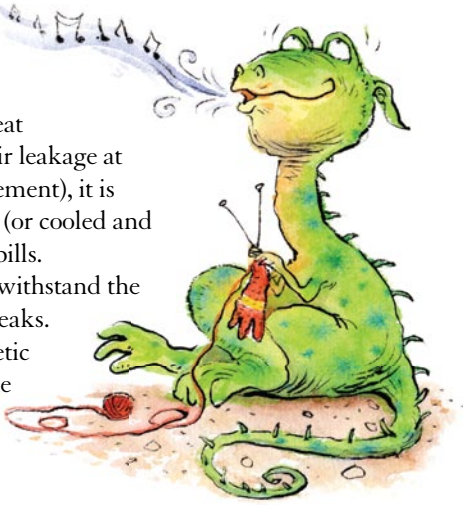
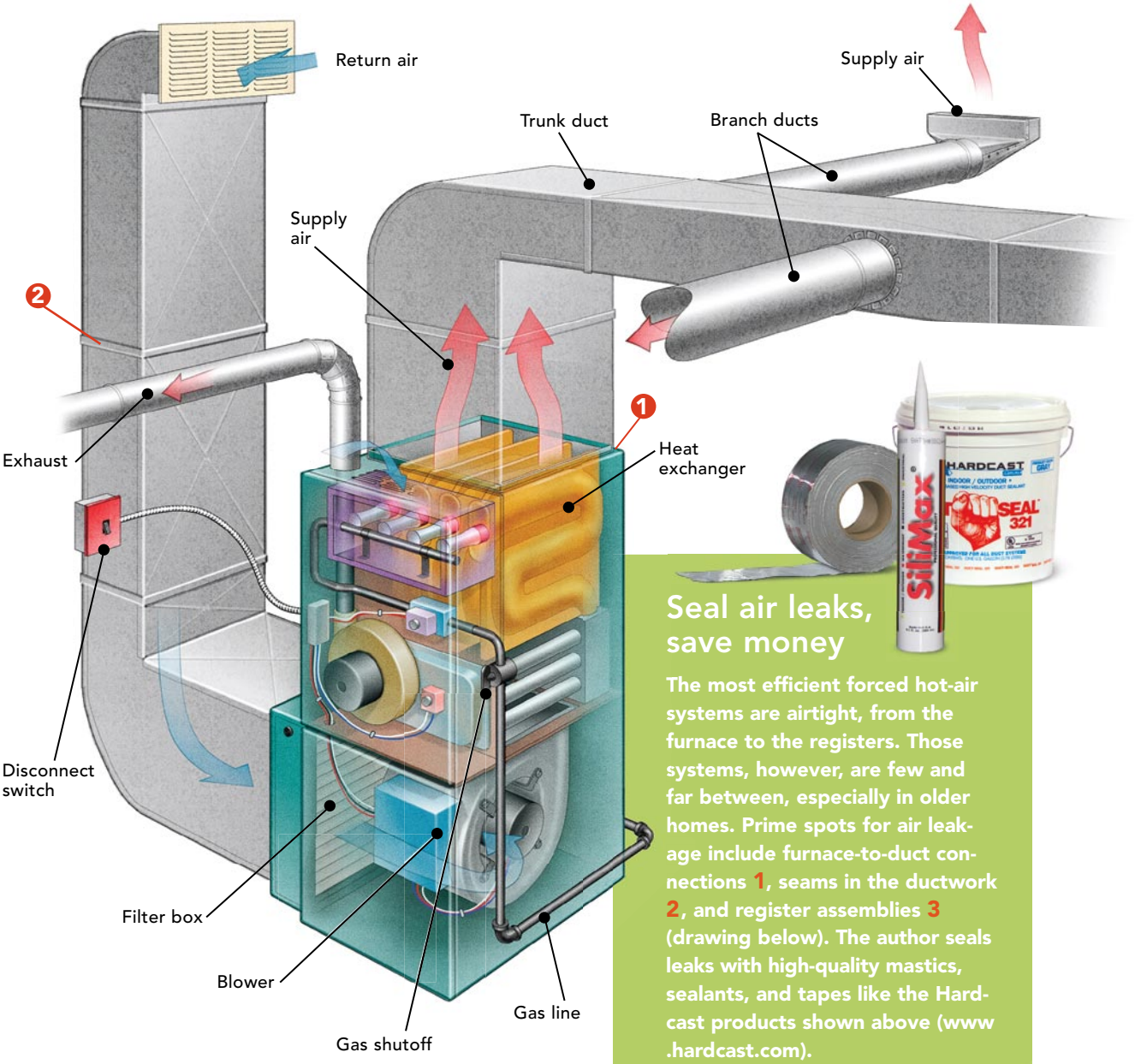


Photo facing page: Courtesy of the manufacturer

FURNACE BASICS

Furnaces use natural gas, propane, oil, or electricity, and are fired when a remote thermostat detects that the temperature in a room has fallen below a preset level. Once in operation, the burner fires in a combustion chamber and warms a heat exchanger (electric furnaces have coils much like a toaster). A blower pushes air over the heat exchanger, or coils, and hot air flows through a series of ducts and enters a home's living spaces through registers in the floors, walls, or ceiling. Ducts also supply return air to the furnace, and combustion gases exhaust through a chimney or direct-vent system.

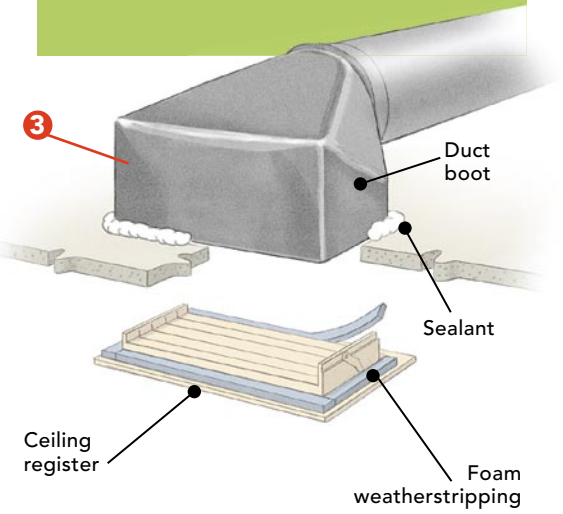


Seal air leaks, save money

The most efficient forced hot-air systems are airtight, from the furnace to the registers. Those systems, however, are few and far between, especially in older homes. Prime spots for air leakage include furnace-to-duct connections 1, seams in the ductwork 2, and register assemblies 3 (drawing below). The author seals leaks with high-quality mastics, sealants, and tapes like the Hardcast products shown above (www.hardcast.com).

Q ***Streaks of dirt are visible around the ceiling registers in our house. What's causing them?***

A **Those streaks are tiny particles of soot blasted across the ceiling** by air leaking from around a register that isn't connected properly. Think of your ceiling as the inner layer of a sandwich. If you had X-ray vision, you'd see the duct boot resting on the attic side of the ceiling with the register below, sandwiching the ceiling between them. If the boot isn't firmly attached, you're heating (or cooling) your attic—typically unconditioned space—which means your energy dollars are being lost to the great outdoors. The same goes for floor registers. In either case, the cure is the same: Remove the register, use a sealant to close the gaps between the boot and the ceiling (or floor), and add foam weatherstripping between the ceiling (or floor) and the register to prevent air leakage.



Q *Our local oil company is offering a $29.95 service special. It seems like a bargain, but does heating equipment need to be serviced every year?*

Just as people should get an annual physical, all heating equipment should receive an annual checkup to maintain peak performance and to keep the home's occupants safe. Part of the service is a test for proper combustion using an analyzer that provides CO (carbon monoxide), O_2 (excess oxygen), and CO_2 (carbon dioxide) levels, as well as net stack (exhaust) temperature. You should ask for a copy of this test, or combustion analysis.

While the internal surfaces of some gas appliances don't need to be vacuumed (unlike oil units), regular maintenance is particularly important for newer high-efficiency models. Also, in all units, the chimney or venting should be inspected periodically to make sure it's not obstructed. Dirty heat exchangers in oil burners rob efficiency, which results in increased fuel usage. A layer of soot just 1⁄16 in. thick reduces operating efficiency by 10%.

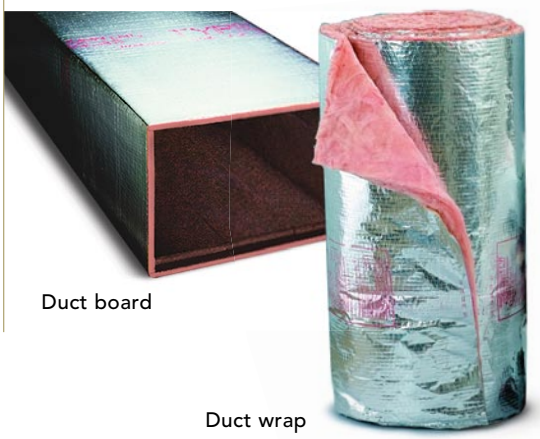
That said, it's not physically possible to clean and tune up an oil-burning appliance properly for $29.95. Companies offering prices that low often pay technicians a flat rate for each call they make; the more they fit into a day, the more profitable it is for them—at your expense. I often see those furnaces six to eight years later, when they're malfunctioning. So accept the fact that if it sounds too good to be true, it probably is, and call in a professional technician you can trust at a believable price.

What should I expect from a service call?

- Preliminary combustion analysis
- Chimney inspection
- Top of boiler removed and combustion chamber cleaned
- Soot vacuumed from all surfaces
- Oil filter replaced
- Oil-burner nozzle replaced
- Reassembly; draft in flue and over burner checked; boiler operation tested
- Final combustion analysis

Q *Our ductwork is located in the attic. There doesn't seem to be as much warm air blowing from the registers as there used to be. Is that my imagination?*

Ductwork that travels through unconditioned spaces (basements, crawlspaces, garages, and attics) needs to be well insulated. Uninsulated ducts waste gobs of energy and create drafts as chilled air spills out of ceiling registers; it's hard to believe how noticeable this is until you've felt it firsthand. Newer codes require R-8 minimum insulation on ducts, but on older flex and duct-board systems, it can be as low as R-2.5. Before you consider more insulation, however, remember that insulation can hide the real problem: air leakage. According to the Department of Energy, you could be losing 40% of the heat through duct leaks. A home-energy audit that includes a duct-pressure test can identify those leaks; sealing them with mastic can result in substantial fuel savings. Once the leaks are sealed, add more insulation around the ducts, either blown-in, loose fill, fiberglass batt, or a duct wrap, as seen below.



Duct board

Duct wrap

Insulation helps, too. *Once all ducts are air-sealed, use insulation to limit heat loss. Owens Corning makes insulated rigid ducts, insulated flexible duct wrap, and foil-faced insulation that can be used to wrap existing ducts (www.owenscorning.com).*

Flexible duct insulation sleeve

Say what?

Ask a heating contractor for advice about your home's systems, and you might get an answer that sounds like it's in a foreign language. Contractors sometimes forget that consumers aren't familiar with the lingo that's second nature among pros. Here, we translate a few of the terms common to the heating-and-cooling industry.

AFUE: ANNUAL FUEL UTILIZATION EFFICIENCY

An indicator of how well gas- and oil-fired equipment uses energy. Translates easily to dollars: A 98%-efficient unit transfers 98¢ of each energy dollar from fuel to home.

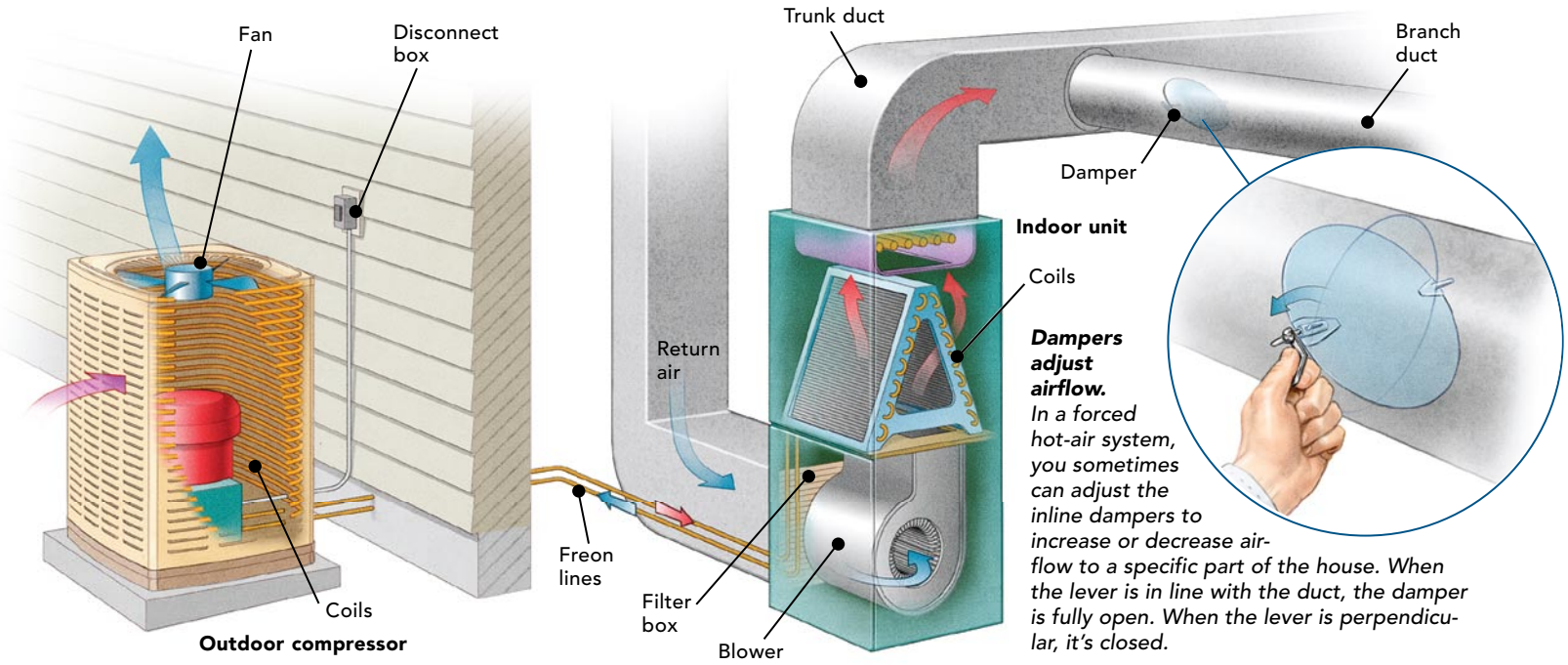
BTU: BRITISH THERMAL UNIT

The amount of energy required to raise 1 lb. of water 1°F. In terms of electricity, 1 watt equals 3.4129 Btu. MBH stands for 1000 Btu per hour.

Product photos this page: Courtesy of the manufacturer. Photo left: Courtesy of the author.

HEAT-PUMP BASICS

Air-to-air heat pumps use pressurized Freon gas to absorb heat from the air outside and transfer it to your home. When the thermostat calls for heating, Freon is pressurized, it condenses, and then it turns to hot liquid. A blower forces air across warm Freon-filled coils and through a system of ducts; warm air is distributed through registers in the floors, walls, and ceiling. At the same time, a fan in the condenser sends cold air outside. You can reverse the cycle for cooling in the summer. (Ground-source heat pumps use a water/glycol mixture to exchange heat energy with the earth.)



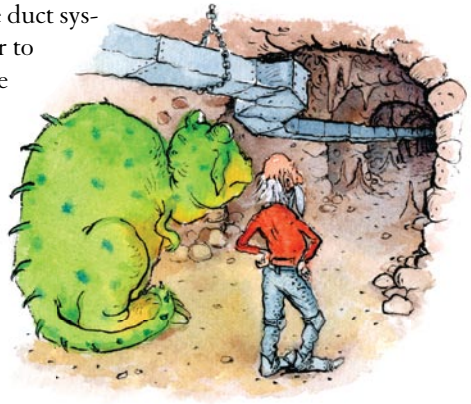
Dampers adjust airflow. *In a forced hot-air system, you sometimes can adjust the inline dampers to increase or decrease airflow to a specific part of the house. When the lever is in line with the duct, the damper is fully open. When the lever is perpendicular, it's closed.*

Q *The temperatures upstairs and downstairs are uneven; some rooms are colder or hotter than others. What's causing this problem? Can it be fixed?*

You're likely describing an out-of-balance duct system. If a forced-air system isn't ducted properly, the flow of supply and return air is unbalanced, resulting, for example, in a ground floor that doesn't stay warm in heating season or a second floor that's not sufficiently cooled in AC season. Sometimes it's due to poor duct design; other times it occurs when air-conditioning is added to a heating system without re-evaluating and possibly resizing the ductwork.

If you have problems with individual rooms and you've made sure all the ducts are connected properly (believe me, I've seen my share of ducts to nowhere), you might be able to adjust the dampers and guide a little more (or less) air to those areas. Dampers are normally located within the first few feet of each branch, or takeoff, and are adjusted by turning an external lever. Generally, when the lever is in line with the duct, the damper is fully open. Airflow also can be regulated somewhat at the register if it's an adjustable model; however, that can create an objectionable noise as air rushes past the louvers.

While adjusting airflow this way could improve comfort, it doesn't help the system to perform better. To do that, you need to call in a pro. A good HVAC contractor uses a nationally approved design program to size an entire duct system properly. Ask the contractor to show you how he or she does the design work, and ask questions. The fix can range from a few simple adjustments to installing a mini-split inverter heat pump in the affected areas to ripping out everything and starting over, costing from a couple of hundred dollars to several thousand.



COP: COEFFICIENT OF PERFORMANCE
The ratio of the energy input of a heating or cooling appliance to its heating or cooling output. The higher the COP, the more efficient the system.

EER: ENERGY-EFFICIENCY RATIO
Overall efficiency related to energy usage. It's calculated by dividing the net-Btu output by the wattage used.

HSPF: HEATING SEASONAL PERFORMANCE FACTOR
Indicates the heating efficiency of heat pumps. The higher the HSPF, the lower the cost to operate the equipment.

MERV: MINIMUM EFFICIENCY REPORTING VALUE
Measures efficiency of air filters. The higher the MERV number, the better an air filter works to capture airborne contaminants.

SEER: SEASONAL ENERGY-EFFICIENCY RATIO
The cooling efficiency of an air conditioner or a heat pump. The higher the SEER number, the lower the cost to operate the equipment.

Q I hear a lot about tuning up furnaces, but how can I boost the efficiency of my heat pump?

Like furnaces and boilers, your heat pump should be serviced annually. Cleaning the coils and changing the filter can increase the heat pump's efficiency by up to 10%. Heat pumps are rated in SEER for cooling efficiency and HSPF or COP for heating efficiency. (See "Say what?" on p. 52.) The higher the numbers, the higher the efficiency and the lower the operating costs.

If your heat pump operates below 13 SEER and 6.5 HSPF (the current minimum standards set by the federal government), you should plan to replace it. When you do, ask for a 410A refrigerant-based system (Carrier calls it Puron). The 410A-based systems are a bit more efficient and a bit more expensive, but the R-22 refrigerant currently in use is being phased out. As a result, it's unlikely to be available when new equipment wears out.

With today's fuel costs escalating, you might also want to consider a hybrid heating system, wherein a fossil-fuel furnace is coupled with a high-efficiency heat pump, allowing you to choose whichever system is least expensive to operate at specific times. These setups often use automatic controls that seamlessly switch from one system to the other based on the internal programming.

Q I keep hearing about "modulating" technology in furnaces and boilers. What's that?

Traditionally, heating equipment operates on one speed: Either it's on, or it's off. The minute a furnace or boiler fires up, it produces the same amount of Btu whether it's trying to raise the temperature of a house 2°F or 20°F, and whether the air outside is -5°F or 50°F. But a number of new, high-efficiency stepped-input ("hi-lo fire") furnaces can operate at two levels: low input or high input, with a lower or higher fan speed.

Because the low-input level can be used when outdoor air temperatures are relatively moderate (roughly 70% of the heating season for many of us), modulating equipment promises fuel savings of 30% or more. When the heat-demand load exceeds the "lo-fire" output, the furnace control steps on the gas to meet demand.

A furnace first. *The York Affinity 33 is the industry's first modulating gas furnace and boasts 98% efficiency (www.yorkupg.com).*

Modulation technology has been limited to boilers—until now. York International's recently released Affinity 33 is the industry's first truly modulating gas furnace that uses outdoor reset, which adjusts the system based on the air temperature outside, to determine how hard it needs to run to meet a home's heat loss (from 35% to 100% in 1% increments). Both the burner and the blower modulate as a team to maximize Btu, and the manufacturer claims 98% thermal efficiency.

Modulation is an almost universal feature found on high-efficiency condensing boilers. Here, too, you'll find products that can achieve 98% thermal efficiency. Virtually all these high-efficiency products use outdoor reset to achieve superior comfort and efficiency.

Q We're not ready to replace our heating equipment right now. What can we do to improve our comfort and reduce fuel bills?

If you've performed the fixes I already mentioned and you're still uncomfortable (or breaking open the piggy bank to meet fuel costs), you might consider fine-tuning your system with an auxiliary appliance. One option is spot-treating one or more rooms with high-efficiency mini-split heat pumps. With efficiencies topping out at 26 SEER and 12 HSPF, these ultraquiet heat pumps give you the option of conditioning just the space you're occupying while letting the rest of the home's mechanical systems hibernate. They're basically self-contained units with supply tubes for refrigerant running through the wall. The best ones use inverter (variable-speed) technology, allowing the units to sip only as much electricity as they need to maintain comfort.

A damper with horsepower. *Motorized dampers allow for controlled airflow through ducts from remote locations and can create heating zones in a formerly one-zone house (www.aprilaire.com).*

If you have a hot-air system, adding humidification can increase comfort while letting you reduce the temperature by several degrees. You can plug in a freestanding unit or have a pro connect one to your furnace for $600 or more.

If you have a central system that's not zoned, a motorized damper system can deliver heat where you need it most. Multiple dampers can be daisy-chained so that several rooms operate as one zone. One caution: It's important to have a good professional do this work.

If you have a hydronic system, you can fine-tune the zones with thermostatic radiator valves, which can be installed in every room except where the thermostat is located. Once you set the dial, the valves open or close automatically based on the room's temperature. They're a good solution in rooms that are chronically overheated or that are seldom used.

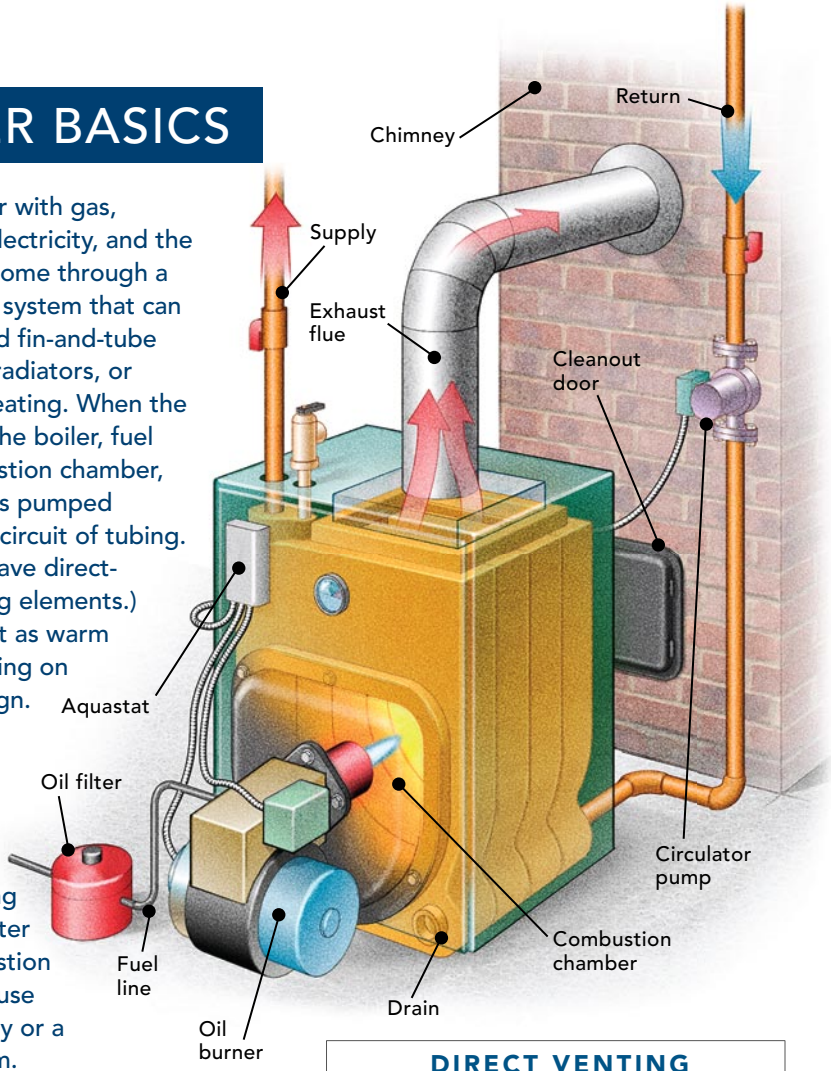
In an uncertain economy, investing in energy—that is, the energy you use in your own home—could be your wisest move. Your ROI (return on investment) begins the second you start using the equipment and can well exceed anything the stock market can yield. You'll add value to your largest investment (your home), you'll be more comfortable, and you'll get to keep more of your hard-earned money.

High-grade your hydronics. *Thermostatic radiator valves fine-tune hydronic heating systems by controlling temperatures in individual rooms. Set the dial to raise the temperature in one room and lower it in another (www.danfoss.com).*

Photos this page: Courtesy of the manufacturers

BOILER BASICS

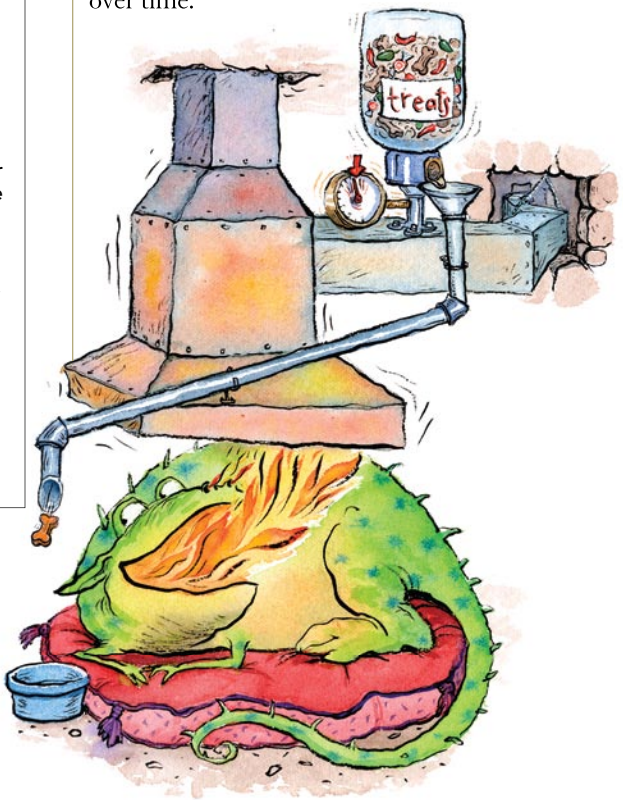
Boilers heat water with gas, propane, oil, or electricity, and the water heats the home through a hydronic delivery system that can include baseboard fin-and-tube radiators, steam radiators, or in-floor radiant heating. When the thermostat fires the boiler, fuel burns in a combustion chamber, and warm water is pumped through a closed circuit of tubing. (Electric boilers have direct-immersion heating elements.) The water can get as warm as 180°F, depending on the system's design. Because hot water expands, a pressure gauge and a relief valve prevent the system from failing due to excess water pressure. Combustion gases exit the house through a chimney or a direct-vent system.



Q *My furnace still works, but my heating bills are sky-high. Should I think about getting a new one?*

Given today's rapidly escalating fuel prices, you really can't afford not to consider upgrading to a new high-efficiency furnace. Older furnaces were constructed with durability, not efficiency, in mind. Trimming 20% to 70% off your fuel bills is a realistic expectation when you upgrade to high-performance equipment.

Your existing furnace most likely has a 60% to 78% efficiency rating, which was once considered respectable. The current federally mandated minimum efficiency for furnaces is 80%, but there are models—hundreds of them—that operate above 92% and qualify for Energy Star rebates. There are even a few that can achieve 98% efficiency by using a feature called "outdoor reset," which modulates both the blower speed and the burner's fuel input. As you might expect, the better the efficiency, the higher the up-front costs. But with the rise in fuel prices and the anticipated 20- to 30-year life span of a furnace, the increased purchase price pales by comparison to the fuel costs saved over time.



Q *What separates low-efficiency heating systems from high-efficiency models?*

One difference is the way the unit is vented. A 78%-efficient furnace (or boiler) vents into a chimney and uses the home's interior air for combustion. New 92%-efficient models are designed for sealed combustion. A direct venting setup draws outdoor combustion air.

Chimney-vented heating equipment continuously drafts heated air out of the house and strips away some of the Btu produced when the furnace is operating. There's also a hidden energy cost: air infiltration. Whenever its burner fires, the chimney-vented unit draws in warm room air to support combustion—air that must be replaced by cold outside air drawn through cracks and gaps in the home's shell. Eliminate that draw with a sealed-combustion model, and your fuel bills could fall by 30% or more.

Cost also separates the top performers from the rest. But the difference in price between 78%- and 95%-efficient gas-fired furnaces has narrowed considerably, to about $1500 for the equipment and installation costs. If your system burns oil, you have fewer choices, and the price gap is wider (about $4000). But with ever-shifting oil prices, it's easier to justify the extra expenditure.