Mechanical Systems

Energy Efficiency Basics for the Old House Owner

Handout compiled by Marc Lennon, Systems Supervisor, Newport Restoration Foundation, and the NRF Education Department

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Resource Adapted from:

American Council for an Energy-Efficient Economy, http://aceee.org/consumerguide/waterheating.htm#lcc

The Best of Fine Home Building: Energy-Smart Homes, Winter 2009.

Gas Networks, http://www.gasnetworks.com/

"Successful Chimney Sweeping," Prepared by the Chimney Safety Institute of America Certification Committee and the National Chimney Sweep Guild Technical Advisory Committee, January 2002.

Additional Resources:

The Chimney Safety Institute of America, http://www.csia.org/

New England Gas, http://www.negasco.com/

The Oil Heat Institute of Rhode Island, http://www.oilheatinri.com/

U.S. Department of Energy, http://www.energy.gov/

Increasing Efficiency in Mechanical Systems

Energy Efficiency Basics for Old House Owners

Mechanical systems are: power, lighting, heating, ventilation, air conditioning, fire and life safety, plumbing, and elevators. Here we'll address **heating, cooling, ventilation and hot water**.

Passive Measures

The National Park Service estimates that passive measures can save as much as 30% of the energy used in a building. These are highly appropriate steps from a preservation perspective.

- Install a programmable thermostat (DIY)
- Turn thermostat down in winter and up in summer - each degree realizes savings.
- Use windows, shades, curtains, shutters, awnings, and vents to control interior environment.
- Control temperature in rooms that are used; establish zones so unused rooms are unconditioned.
- Clean radiators and forced air registers.
- Have your furnace or boiler cleaned and serviced regularly.
- Make sure ducts and pipes are well insulated and sealed.
- Place a reflector barrier between radiators and outside wall (particularly if wall is uninsulated).
- Replace steam vent at each radiator (1-pipe system) or steam traps (2-pipe system).
- Turn down the temperature on your hot water heater.
- Don't block hot air or cold return registers with furniture or other barriers.
- Offset electricity use with the purchase of renewable energy through your local energy provider.

Active Measures

Active measures include: new boilers or furnaces; reconditioning radiators or fan coil units; new heat pump systems; adding portable fans, dehumidifiers, or heaters; installing whole-house fans; introducing air-conditioning systems. These potentially invasive changes can adversely effect the historic character of your house, your budget (initial costs, lifecycle costs, and unanticipated side expenses), and the energy efficiency benefits realized. Important considerations:

- Consult Professionals! Get advice from several contractors or experts before proceeding. Check licenses and reputations of professionals. State licensing board: www.ri.gov/Licensing/
- Every effort should be made to select mechanical systems that require the least intrusion into the building's historic fabric. Consider consulting a preservation organization or professional.
- Unused fireplaces and closets can be converted to ductwork and electrical boards. If your building has cavity walls, these are good places to hide wiring. False floors or walls can also hide mechanical and electrical systems. Consider combining air and water systems that combine pipe and duct systems, therefore allowing for greater flexibility in installation.
- Air conditioning units should placed so that they are not visible when looking at the main façade.
- Ventilation is always an important consideration, especially when new systems are installed.

Sources used and paraphrased:

- National Trust for Historic preservation: http://www.preservationnation.org/information-center/sustainable-communities/weatherization/
- House-Energy Project: http://www.house-energy.com/
- National Park Service Brief #3: http://www.nps.gov/history/HPS/tps/briefs/brief03.htm
- Chimney liner article: http://www.oldhousejournal.com/chimney_liners/magazine/1465

energyspeak

YOUR GUIDE TO TALKING THE TALK

The language of energy efficiency

Annual fuel utilization efficiency (AFUE)

A measure of the fuel efficiency of a heating system under normal operating conditions. Expressed as a percentage, it indicates the ratio of heat output of a boiler or furnace to the amount of fuel energy consumed. An 80% AFUE, then, means 80% of the fuel energy consumed by a furnace is heat delivered to the home. AFUE takes into account flue losses but not leakage of heated air through ductwork. Because it measures actual performance, AFUE is always lower than combustion efficiency (see below).

Boiler

A system used to heat water for hydronic (water-based) heating. Most boilers are gas- or oil-fired, although some are electric or wood-fired. New modulating boilers (photo below) have rated efficiencies (AFUE) of 92%.

Btu

Short for British thermal unit, the amount of heat required to raise 1 lb. of water (about a pint) by 1°F in temperature. One Btu is equivalent to 0.293 watt-hours.

Building envelope

The outer shell of a house, including the foundation, exterior walls, roof, and windows. A tight envelope is critical to a home's energy efficiency.

Coefficient of performance (COP)

An energy-efficiency measurement for ground-source heat pumps, it is the ratio of useful energy output (heating or cooling) to the amount of energy put in. A higher COP indicates a more efficient device.

Combustion efficiency

The efficiency at which a combustion appliance (furnace or boiler) operates at its rated output. It does not reflect chimney losses and is always higher than annual fuel utilization efficiency (see above).

Energy-efficiency ratio (EER)

A measure of the operating efficiency of an air conditioner or heat pump at a specific temperature, calculated by dividing the Btu of cooling output by the power consumption in watt-hours. The higher the EER, the greater the efficiency.

Energy factor (EF)

A rating of energy performance for dishwashers, clothes washers, water heaters, and certain other appliances; the higher the energy factor, the greater the efficiency. It generally reflects the percentage of energy going into the appliance that is turned into useful energy, but it is calculated differently for different appliances.

EnergyGuide

This label from the U.S. Federal Trade Commission lists the expected energy consumption of an appliance, heating system, or cooling system, providing a basis for comparison with other products in that category.

Furnace

An appliance used to heat air for a forced-air heating system. Furnaces can be fueled by gas, oil, wood, or electricity.

Ground-source (geothermal) system

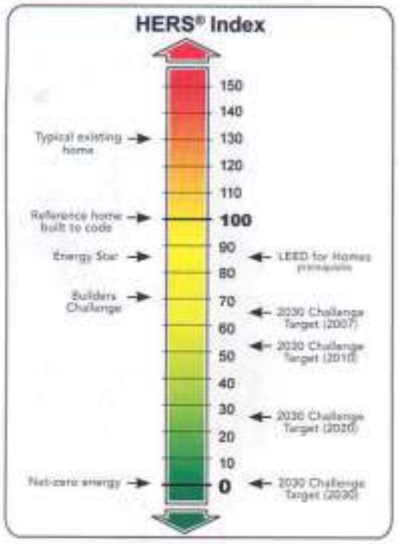
A home-heating and -cooling system that uses the relatively constant temperatures beneath the ground to condition a house. In heating mode, heat from fluid circulated through underground pipes is transferred to the home via a heat exchanger; in cooling mode, heat extracted from the home is dispersed underground.

Heating seasonal performance factor (HSPF)

A measurement of efficiency for an air-source heat pump in heating mode; it's the ratio of the pump's estimated heat output over the heating season (in Btu) divided by its power consumption for the season (in kilowatts). The most efficient heat pumps have HSPFs of 8 to 10.

Photo bottom left: Daniel S. Morrison

The Best of Fine Homebuilding: Energy-Smart Homes, Winter 2009, 104.



HERS Index

A scoring system for energy efficiency, the home energy rating system (HERS) compares a given home to one built according to the 2006 International Energy Conservation Code. A code-built home has a HERS Index of 100, and a home that uses no energy (or produces all the energy it uses) has a HERS index of 0. So the lower a home's HERS Index, the more energy efficient it is. A typical existing home has a HERS Index of 130.

Kilowatt

A thousand watts; used to measure the amount of electricity needed to power a home.

Kilowatt-hour (kwh)

A measure of electricity usage equal to the use of 1000 watts over a one-hour period. A 100w lightbulb burning for 10 hours consumes 1kwh.

Low-emissivity (low-e) coating

A very thin metallic coating on window glazing that permits most of the sun's short-wave (light) radiation to enter, while blocking up to 90% of the long-wave (heat) radiation. Low-e coatings boost a window's R-value and reduce its U-factor (see drawing at right).

Net metering

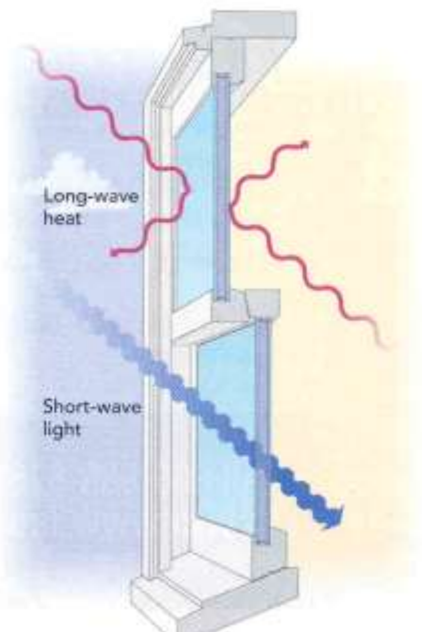
An arrangement through which a homeowner who produces electricity using photovoltaics or another alternative power source sells any excess electricity back to a utility company.

R-value

A measure of effectiveness in stopping heat flow, most often used to indicate the effectiveness of insulation. The higher the R-value, the less heat transfer there is. It is the inverse of U-factor (see below).

Seasonal energy-efficiency ratio (SEER)

A measurement of the efficiency of a central air conditioner or heat pump operating in cooling mode; it is the ratio of the estimated seasonal cooling output (in Btu) divided by the seasonal power consumption (in watt-hours). Higher SEER ratings indicate more efficient equipment; in 2006, the minimum SEER for home-cooling systems was set at 13.



Solar heat gain coefficient (SHGC)

Used to rate window performance, it designates the fraction of solar radiation admitted through a window, which is released as heat inside the home and is expressed as a number between 0 and 1. The higher the SHGC, the more solar heat is allowed in; the lower the number, the more effective the window is at reducing heat gain in summer. Climate, orientation, and external shading should be considered when determining the best SHGC for your windows.

Therm

A unit of heat equal to 100,000 British thermal units (Btu); commonly used for natural gas.

U-factor

The rate at which a window, door, or skylight conducts nonsolar heat; it is the inverse of R-value. The lower the U-factor number, the better the window will keep heat inside a home on a cold day.

Watt

A measure of electric power at a point in time, reflecting either capacity or demand.

Zero-energy house or net-zero energy house

A house that produces, on average, as much energy as it uses. This is possible through the combination of a tight envelope and high-efficiency appliances, lighting, and heating and cooling systems typically supplemented by solar or wind power. Usually, a zero-energy home produces more energy than it needs during some periods (such as a solar home whose meter runs backward on a sunny day) and draws from the electrical grid or another outside energy source at times of low energy production.

Chart top left: Courtesy of RESNET. Photo center: Justin Fink. Drawing: Dan Thornton.

Best of Fine Homebuilding: Energy-Smart Homes, Winter 2009, 106.

Energy-Saving Thermostats

BY SEAN GROOM

These programmable gizmos are simple to install and can save you money

Instead of turning down the thermostat on the way to bed and again on the way out the door, you can cut home-heating costs and count on a reliable, comfortable temperature with one of today's programmable thermostats. Basic models ($30 and up) store different settings for weekdays and weekends. More advanced models ($90 and up) store a different program for each day of the week.

Minimize operating time to save money

Whether a thermostat is manual or programmable, your savings result from the *setback*, or the reduction in temperature from the typical occupied setting. Studies by the U.S. Department of Energy have found that the energy required to raise a home's temperature to its normal level approximately equals the energy saved as the temperature falls to the lower setting. For each degree of setback over an eight-hour period, you'll reduce energy consumption by 1%; the longer the setback, the more energy savings you enjoy.

During the heating season, utility companies recommend a 68°F setting in the morning and evening and 55°F overnight and when you're not home. You can economize on cooling costs with a setting of 78°F to 85°F when you're out or sleeping.

Check for compatibility

A programmable thermostat has to be compatible with your HVAC system. Be especially careful when choosing one for use with heat pumps or radiant floors. A temperature setback in heating mode can cause a heat pump to operate inefficiently. And because high-mass radiant floors are slow to lose and gain heat, temperature setbacks have to be timed differently.

Finally, look for an Energy Star rating, which ensures the thermostat is capable of four daily temperature settings and is preprogrammed for efficient operation. □

Sean Groom is a freelance writer in Bloomfield, Conn. Mark Eatherton, a heating contractor in Denver, provided technical information.

Adapted from *The Best of Fine Homebuilding: Energy-Smart Homes*, Winter 2009, 48.

Heating System Maintenance is Important

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.

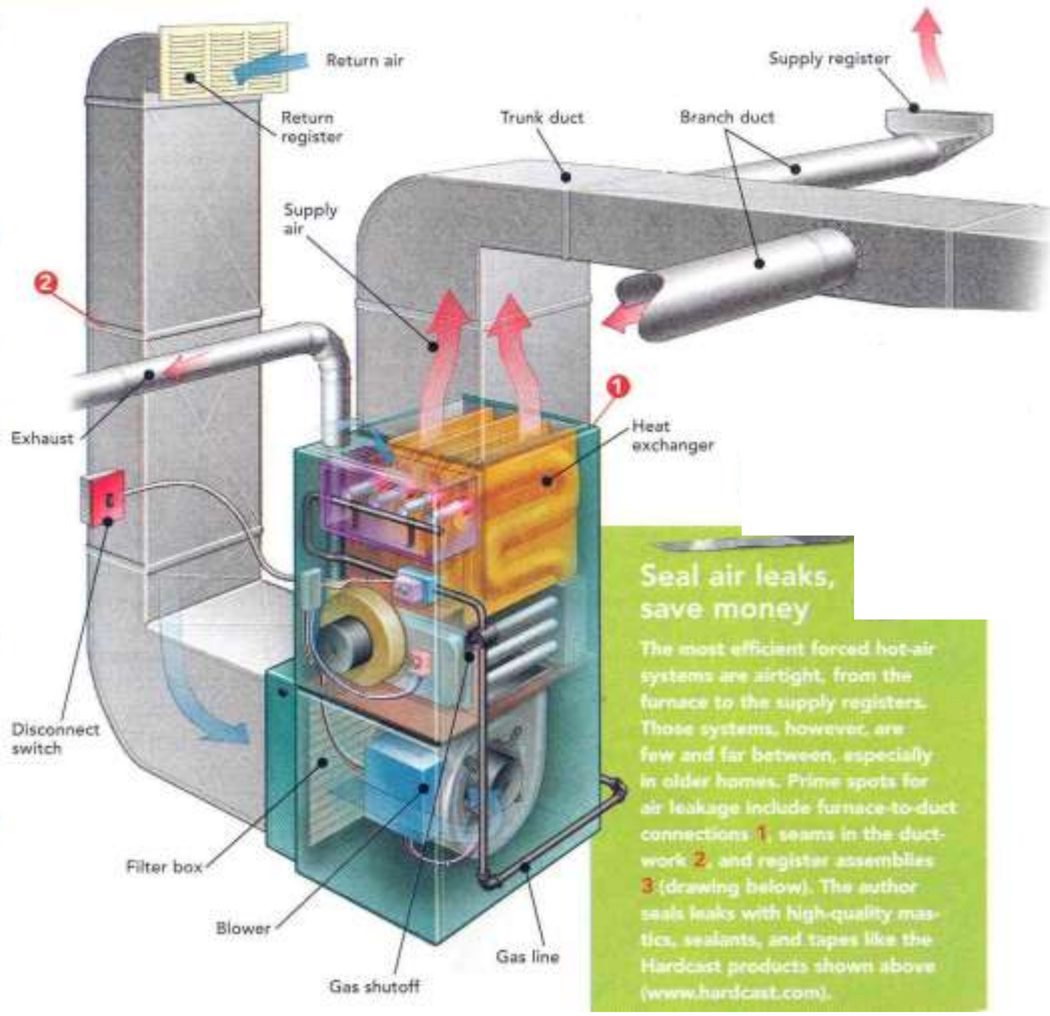
Dirty heat exchangers in oil burners rob efficiency by 10%. That said, it's not physically possible to clean and tune up an oil-burning appliance properly for $29.95. Companies offering prices that low often pay technicians a flat rate for each call they make; the more they fit into a day, the more profitable 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 you can trust at a believable price.

Adapted from *The Best of Fine Home Building: Energy-Smart Homes*, Winter 2009, 58.

FURNACE BASICS

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 the home's living spaces through registers in the floors, walls, or ceiling. Ducts also supply return air to the furnace, and combustion gases exit the house through a chimney or direct-vent system.



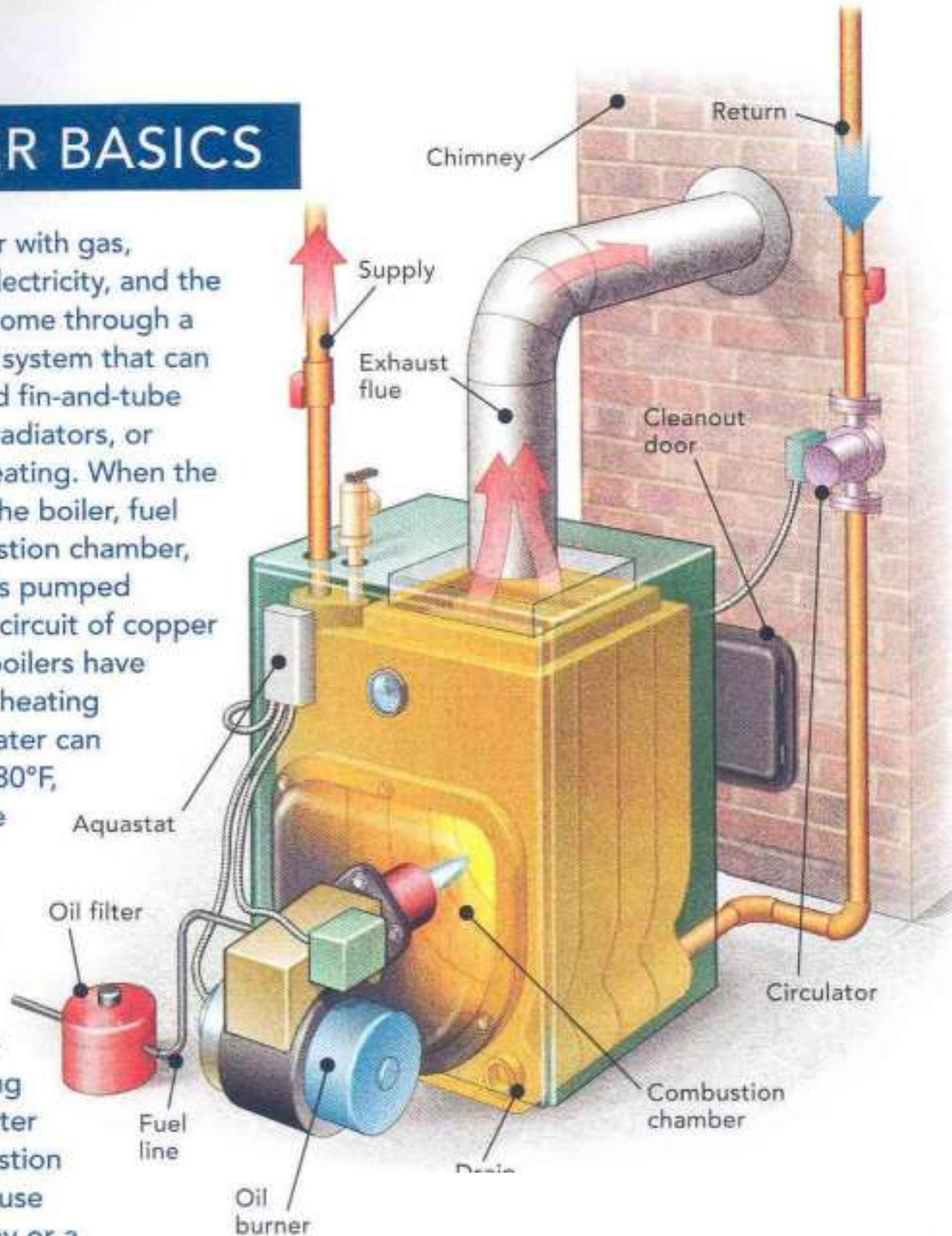
Seal air leaks, save money

The most efficient forced hot-air systems are airtight, from the furnace to the supply 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).

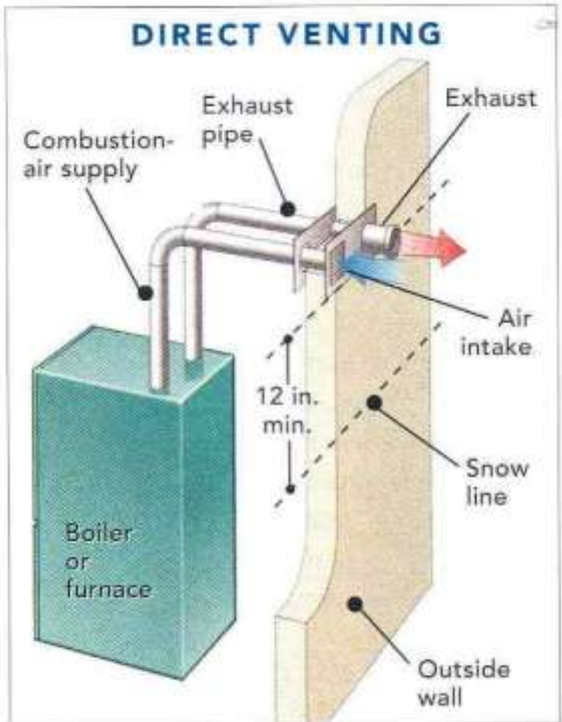
Adapted from *The Best of Fine Home Building: Energy-Smart Homes*, Winter 2009, 57.

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 copper 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.



Adapted from *The Best of Fine Home Building: Energy-Smart Homes*, Winter 2009, 61.



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

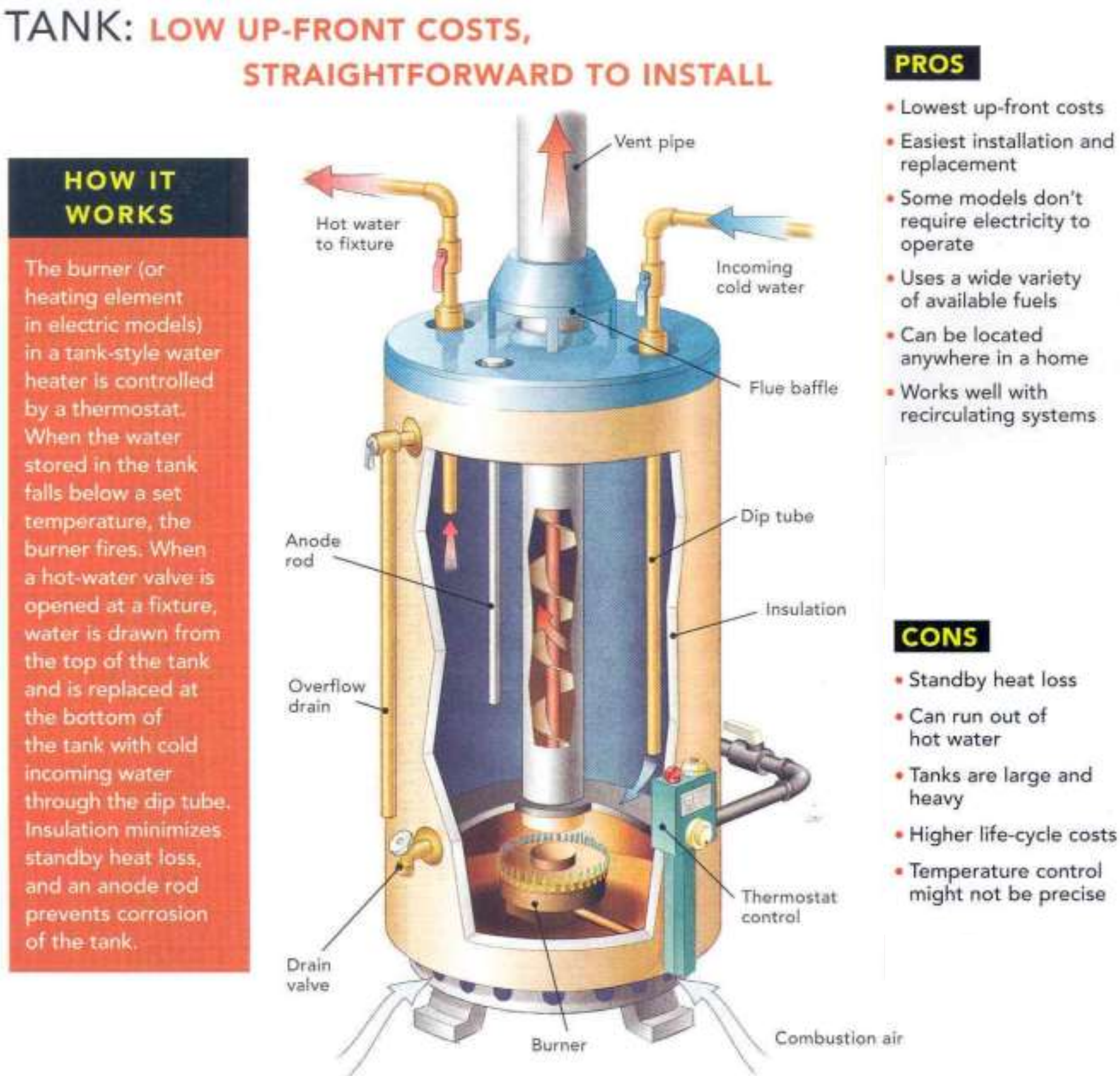
One difference is how the unit is vented. A 78%-efficient furnace (or boiler) vents into a chimney and uses the home's interior air for combustion. New 92%-efficient models are designed for sealed combustion. A direct venting setup draws outdoor combustion air.

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.

Adapted from *The Best of Fine Home Building: Energy-Smart Homes*, Winter 2009, 61.

Tank-style Water Heater



Adapted from *The Best of Fine Home Building: Energy-Smart Homes*, Winter 2009, 85.

Tankless Water Heater

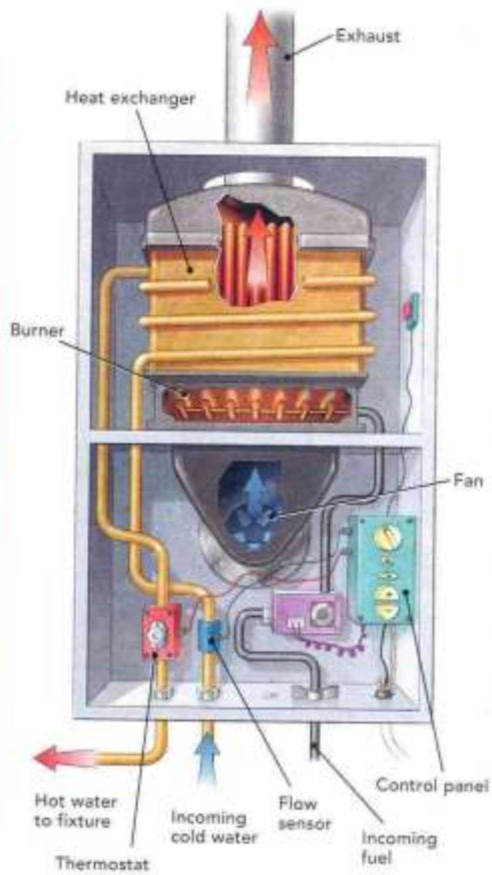
TANKLESS: CONTINUOUS HOT WATER WITH LONG-TERM SAVINGS

TANKLESS OR ON-DEMAND WATER HEATERS don't keep a supply of hot water on hand; they heat water only as needed. Tankless models used as a home's primary hot-water source typically are fueled by gas, but some electric models are available. Although they minimize standby heat loss and consume less energy than tank-style models, tankless water heaters have drawbacks of their own.

On the one hand, they require a specific demand for hot water before they turn on (at least ½ gal. per minute), which makes them tricky to use with low-volume recirculating systems. On the other hand, too much demand for hot water at one time (two or more people showering at once, for example) can test a tankless heater's capacity. The temperature of incoming water can affect the heater's performance and must be considered when choosing the right size. Also, endless hot water can be abused, diminishing or eliminating energy savings. Finally, retrofitting a tankless water heater can be an expensive proposition.

HOW IT WORKS

Tankless water heaters (also called flash or instant water heaters) turn cold water hot almost as quickly as it can flow through the unit. When a hot-water valve is opened at a fixture and water begins to flow through the heater, the flow sensor fires the burner (or heating element in electric models). Water lines coil around the heat exchanger, heating water to the desired temperature. When the valve is closed, the flow sensor turns off the burner.



PROS

- Lower life-cycle costs
- Endless hot water
- Runs only when needed, offering the potential to save energy
- Accurate temperature control
- Small and space-saving; typically wall-hung

CONS

- Higher up-front costs
- Complicated installation; larger fuel lines often required
- Electricity required for most models to operate
- Untreated water can lead to scaling and reduce or halt flow
- Can suffer freeze damage if improperly installed
- Minimum hot-water flow required
- Recirculation is more difficult, with potential to compromise warranty

Adapted from *The Best of Fine Home Building: Energy-Smart Homes*, Winter 2009, 86.

Indirect Water Heater

Features

Attractive Quality Silver finish
Durable plastic jacket for rustproof finish even in moist environments.

Constructed of type 316L stainless steel
with tolerances for high temperatures of operation. Superior corrosion resistance.

New Extra Large High Output Cupronickel Heat Exchanger
for 20% increased performance. Maximum heat transfer efficiency with more surface area, delivering larger amounts of hot water. Supplies 3-5 times more recovery compared to conventional heaters.

Environmentally Safe, CFC-free water-blown foam insulation
2 inches thick; allows less than 1/2 degree F per hour heat loss; the best in the industry.

Lifetime Warranty Protection Plan

Easy to install and maintain

Immersion type control
provides fast response.

Installation versatility
with either zone valve or circulated pump.

Full line of 7 different models and sizes
to meet all your hot water demands.

Very efficient
Reduces fuel cost when operated with high efficiency boiler.

New outlet extractor tube
delivers 5–7% more hot water

How the Super Stor Ultra Works:

The SuperStor Ultra is true advancement in hot water generation. By tying the Ultra into your existing or new boiler as a separate zone with a circulator or zone valve, it will start the boiler only when the Ultra requires hot water and transfers heated energy through the high output exchanger to produce larger amounts of hot water.

Energy Efficient operation

The Super Stor Ultra's 2" to 3" thick insulation quality, connected to a modern boiler system will reduce your operating cost to produce hot water. With today's increasing fuel costs the Ultra will provide the homeowner fast pay back over conventional methods of heating hot water!

Limited Lifetime Protection Plan

Super Stor Ultra's Limited Lifetime Protection Plan will give homeowners the peace of mind that their water heater is covered by the industry's strongest warranty.

Maintenance-Free Operation

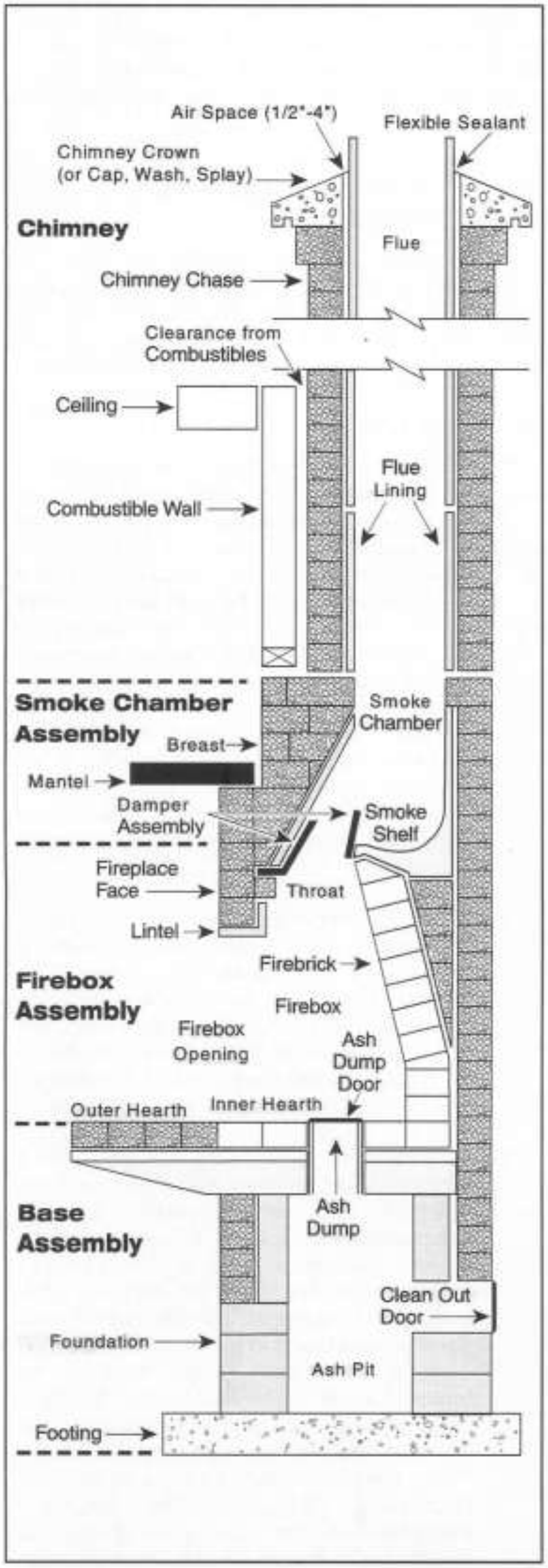
Super Stor Ultra does not need expensive maintenance check-ups. Its simple design requires virtually no maintenance, saving money on costly service calls.

Ultra High Output Heat Exchanger

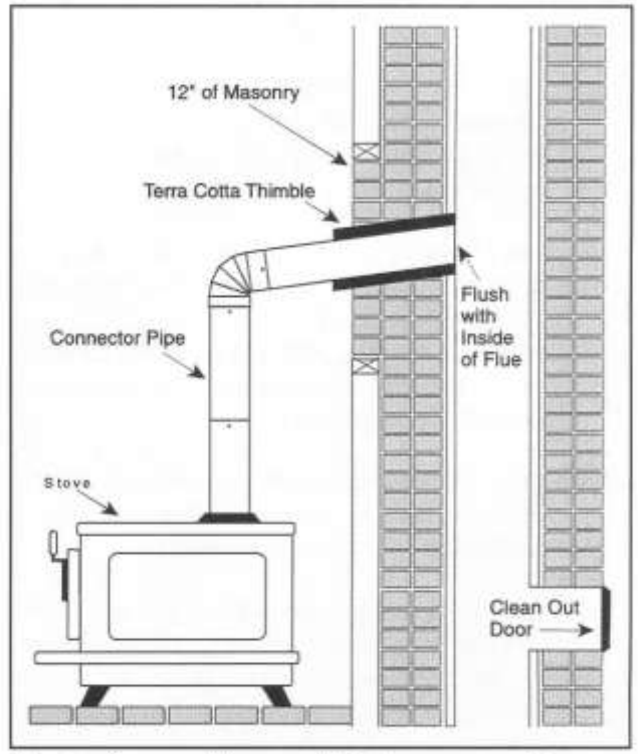
Our Engineering Department has developed the Ultra High Output Heat Exchanger adaptable to new or older boiler systems. The heat exchanger's increased internal size and external surface area gives the Ultra greater recovery performance. This way the Super Stor Ultra has two or more times the recovery rate of gas fired water heaters, and supplies as much as five times the amount of hot water as a comparably sized electric water heater.

Attractive Design

The Super Stor Ultra's attractive appearance will assure each customer that they have installed a superior water heater. The Ultra's silver color will match any old or new boiler color adding to the system's overall appearance.



Parts of a masonry fireplace



Freestanding wood stove vented into a masonry chimney

Frequency of Inspection

The National Fire Prevention Assoc. (NFPA 211) recommends that all chimneys, fireplaces, and vents be inspected annually. In addition to this requirement, there are other times when chimney and venting systems should be inspected, such as:

1. After any unusual or sudden occurrence event, such as a chimney fire, lighting strike, or earthquake.
2. Prior to purchasing a home with an existing chimney or vent.
3. Whenever changes are made to a chimney or vent system, including replacement of connected appliances.
4. Prior to major system repairs.

"Successful Chimney Sweeping," Prepared by the Chimney Safety Institute of America Certification Committee and the National Chimney Sweep Guild Technical Advisory Committee, January 2002, 3-4 and 3-5.