Selecting the right heating system

By Martin S. Harris

If you look at a map of the U.S. showing zones for plant hardiness, you'll see a climactic range all the way from zone 3 (Northern New England and the upper Plains states) to zones 10 and 11 in Southern California and Florida). Zones 10 and 11 are the only places where buildings might be constructed without heating systems, and so readers in that area need not worry about the subject of this discussion. For all the rest of us, the question is not whether to install a heating system, but rather what type to choose.

A couple of centuries back, there would have been one choice, a fireplace. By the 1830's, cast-iron stoves were becoming available. By the 1880's, people were installing gravity hot-air furnaces; and before the turn of the century, steam and hot-water boilers as well. Electric heat came into the residential market in the 1910's and '20's, about the same time that some Californians and Floridians began experimenting with solar-based systems. Since then, we've improved combustion efficiencies and distribution systems, but we've developed no new basic designs.

The same basic pattern holds for heating fuels: wood and then coal, gas and oil by the turn of the 20th century, electricity and solar after that. A few hydroponic greenhouses are using radio-activity waste heat from generating stations, but all the rest of us are either still in the carbon-fuel stage or tentatively experimenting with solar.

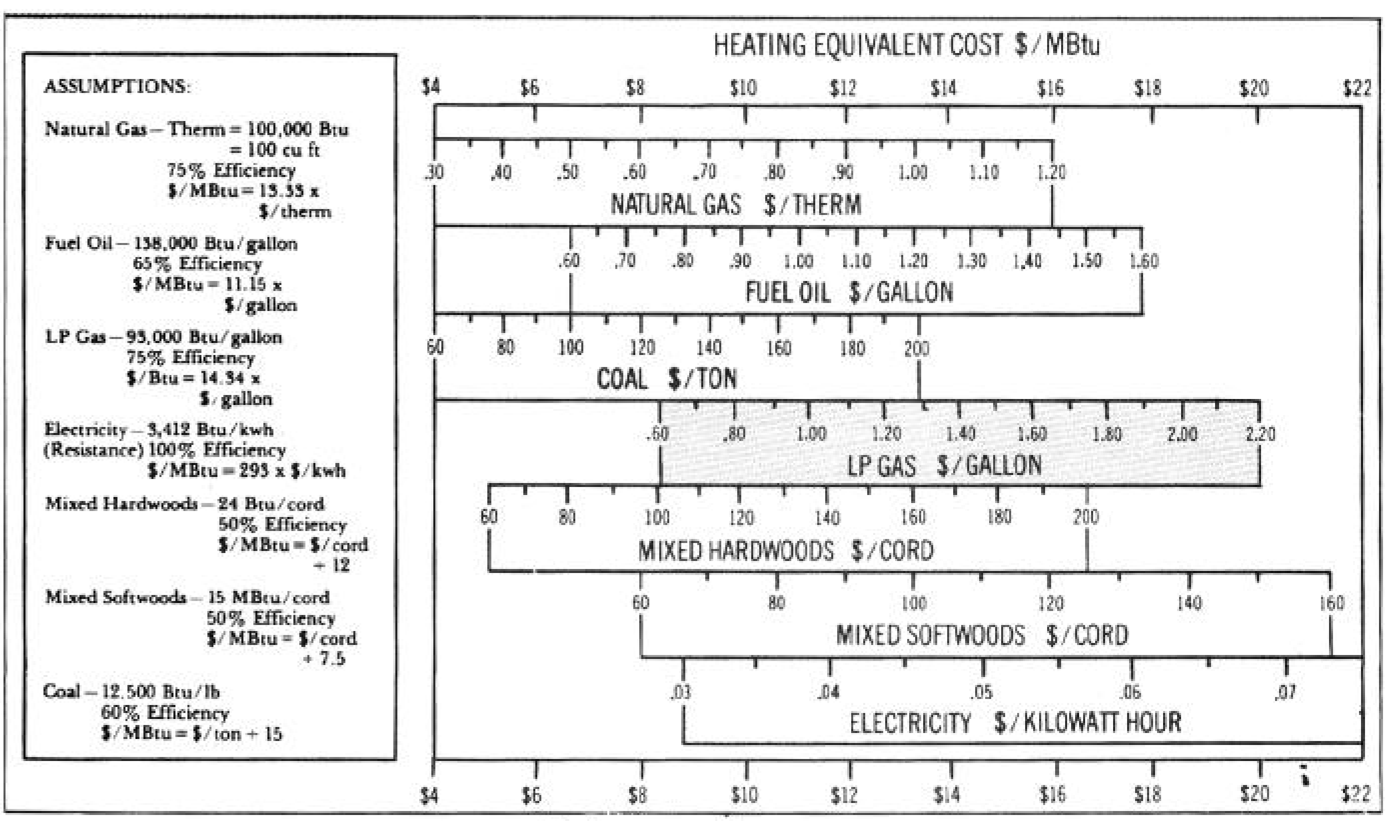
Today's problem is that there's such a wide range of fuels, combustion systems, and system efficiencies that making a design choice seems like a daunting task. Actually, it isn't.

In terms of pure cost-effectiveness (the largest amount of heat delivered inside the living space per dollar of fuel cost) there's only one choice: a state-of-the-art ultra- high-efficiency gas-burning furnace or boiler. If you want to go outside the dollar economy, there's also only one choice: wood (except for you West Virginians who own your own coal seams), for which you don't count your time as a harvesting cost.

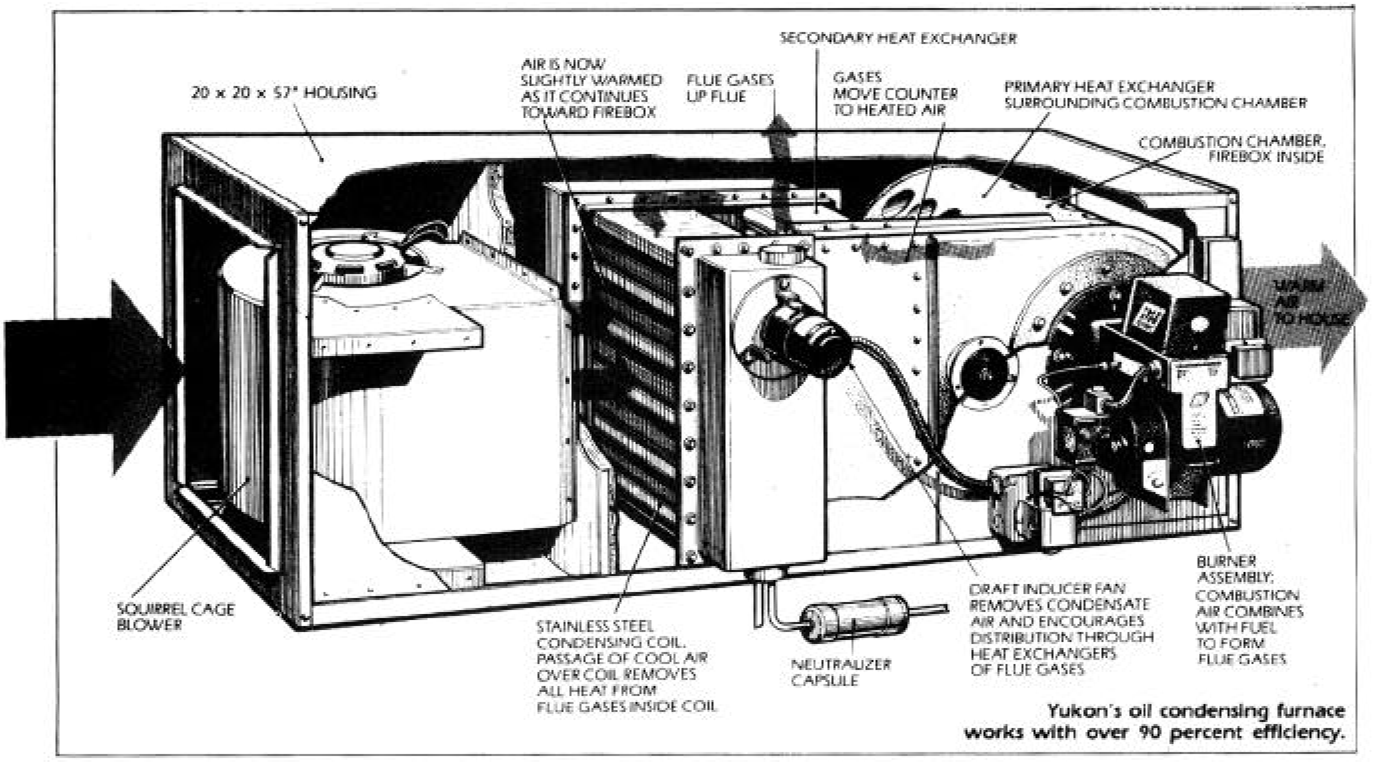
Nevertheless, the most popular system remains the domestic oil burner, consuming (usually) No. 2 fuel oil to heat water for a hydronic system, to make steam for a steam system, or to heat air for—what else—a hot-air system.

Steam probably hit its peak of popularity back in the '50s, and since then the residential market has been about split between baseboard hot-water and ducted hot-air. The latter is usually viewed as lower in cost and quality, but when built right that isn't true.

Wood came back into favor briefly in the 70's when oil prices went up,



Fuel cost comparison



Yukon's oil condensing furnace works with over 90 percent efficiency.

This cut-away drawing of an ultra-high-efficiency unit shows how those 90+% numbers are achieved. Note that no chimney is needed—a boon to cash-strapped first-time builders or owners of an old place with a substandard masonry stack.

but has since declined because it's neither cheap nor clean nor automatic.

Solar, on the other hand, hasn't made much market penetration because oil is still artificially cheap and can underprice the hardware costs for all except simple passive solar systems.

Coal is a "fringe" fuel, popular in limited areas just like wood pellets or chips, various kinds of bio-mass, geothermal, land-fill methane, and so on. Another "fringe" fuel is waste oil: remarkable strides in the technology of this one have been made in just the last few years, and I would count it as the only real innovation in the space-heating field. Probably the best way to analyze this range of choices is to look at each in terms of strengths and weaknesses, as follows:

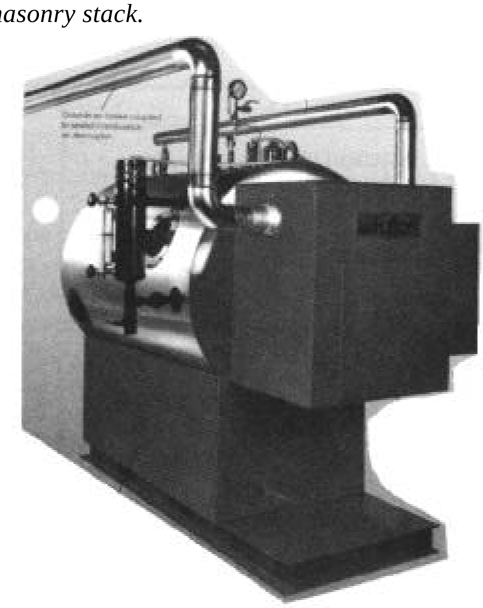
Wood/coal

Let's start with wood or coal. Unless you require automatic stoker systems, wood or coal stoves are the least expensive and least complex way to heat a house, hardware-wise.

Whether they're the cheapest fuel-wise depends on how you cost out your fuel-acquisition method. They're the least efficient, combustion-wise (the quantity of heat delivered vs. the theoretical heat content of fuel burned), about as bad as space-heating electricity from a nuclear plant; well below 50%.

That's for relatively modern units; old stoves can easily be down around 20%, fireplaces half that number. On the other hand, stoves don't require ducts or piping, registers or baseboard convectors, thermostats or fuel pumps. They don't require professional maintenance, and they don't even require a masonry chimney, now that insulated metal stove-pipe systems are available.

On the other hand, they're not cheap to operate if you have to buy all your fuel at top-dollar retail prices. They're dirtier and more labor-intensive to operate than gas or oil systems. Not all stoves will even hold a fire overnight or while you're off at work during the day. And finally, most mortgage-writing banks today won't accept stove-type heating systems.



Fulton pulse combustion steam boiler

Oil

Oil, specifically No. 2 fuel oil, the same viscosity as diesel fuel, is the basis for more extensive steam, hot water, or hot-air systems. In fact, some of the older ones are oil-burners which have been converted from coal or wood, back in the '40's and '50's when the going price was 6 cents per gallon as compared to almost a dollar today.

Heavier and cheaper oil, up to No. 6, is used in industrial applications, but it requires special pre-heat and pumping equipment.'

No. 1—kerosene viscosity—is used in cookstoves and space heaters, some of which have such high combustion efficiencies that they require no venting.

Oil for single-pipe steam was popular back before WWII: it requires a fairly bulky radiator at each window and a fairly bulky combustion unit, usually in the house basement. Most of these old-timers are insulated, pipes and all, in asbestos: be real careful with the legalities in renovating or removing such systems.

Oil for dual-pipe hot-water was more expensive but a quieter-operating system, and therefore considered to be higher quality; it used either radiators even larger than steam units or else long base-board convector units.

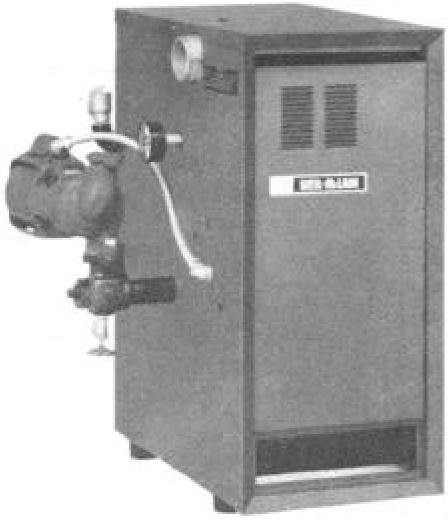
Oil for hot-air can be a high-quality system, if the ducts are large enough to keep air velocities low, the operating systems quiet and draft-free, and a cold-air-return system provided so room doors can be kept closed.

Unfortunately, it's been easy for installers to save pennies by undersizing ducts and even skipping the cold-air returns, so hot-air systems have developed a reputation for poor quality. Lots of all this stuff—ducts, pipes, registers, radiators, and so on—is available on the salvage market today at very modest prices. Most older oil-fired units are lucky to achieve a combustion efficiency of 67%, while the newer ones are usually up around 85%.

There are one or two ultra-high-efficiency oil-fired units—Yukon is one trade name—with a combustion efficiency in the low 90's.

Gas

To get a wider choice of combustion units in the 90% range, one must turn to gas. Gas-fired systems have been around about as long as oil, in the underground piped natural-gas service areas. Since WWII, bottled gas, usually liquified propane, has enabled consumers to use the product out in suburbia and the countryside beyond the gas mains. Most appliances are built for easy conversion to either fuel. No matter which gas is burned—piped-in or bottled, natural or LP—the rest of the distribution system is the same as for oil: supply and return pipes for hot water and baseboard convectors, supply and return ducts for hot-air registers and grills. The combustion efficiency difference for the ultra-high units is based on a process called condensing, where heat is drawn not only from the flame of combustion but also from the vapors ' of the combustion process. Ultra-highs do such a good job of this that they need no conventional chimney, only a 3/8 inch drain for water condensate and a 1 and ½ inch plastic pipe for CO_2 and H_2O exhaust. They're tiny, too; unlike earlier coal or oil burners, these units are no bigger than 3 or 4 cubic feet in size for the average size house.



This gas-fired boiler manufactured by a well-known member of the industry is typical of modern combustion systems which run in the mid-80% range of combustion efficiency. That's a substantial advance over units of the '60's and '70's which rarely got their combustion efficiencies above the mid-60% range. Payback to shift over usually occurs in the 4-5 year range, although, ironically, the better the insulation level, the slower the payback on combustion efficiency.

Electric

Electric-heat advocates sometimes argue that their system is 100% efficient, that every watt or electricity consumed is converted into building heat. That's technically true within the building, but such accounting conveniently forgets the combustion inefficiency back at the generating station, the line loss in moving electricity to the consumer, and the fact that even the supposedly inefficient oil burner warms a basement which in turn warms the upper floors. Electric heat is cheap to install, no doubt about that. With no pipes or ducts, it costs far less than, say, hot-water or hot-air to put in wiring and baseboard resistance heating units which look much like baseboard hot-water convectors. It's also, in most parts of the countryside where electricity costs 8 to 10 cents or more per kilowatt hour-sometimes even more under a winter-rate schedule—far more expensive to operate. If there's a strength to electric heat (beyond the low installation cost, that is) it's that it can be used to beef up weak areas in a conventional system; extra heat in a bathroom, for example, or in a study which is infrequently used.

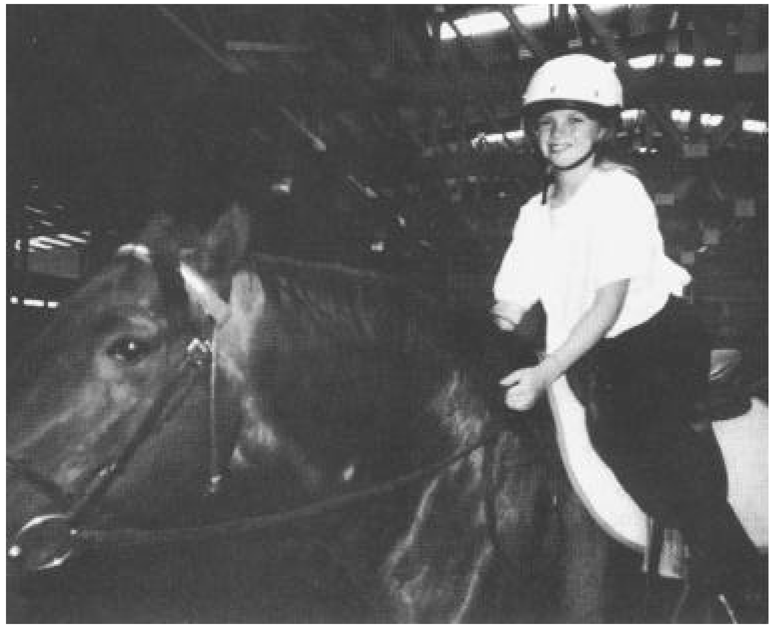
Solar

By the same selective accounting, solar advocates sometimes argue that their system uses zero-cost fuel. That's true. And it's a fact that the simplest kinds of passive solar -greenhouse glazing, for example, are highly cost effective. Solar's problem lies in the cost of its plumbing, in the hardware needed to store heat until it's needed and to move it to places where the sun doesn't shine. It's the cost of collectors and piping, pumps and automated controls, of storage banks and re-distribution systems, which makes it tough for supposedly free-fuel solar to compete with, say, dollar-a-gallon oil. That's not to say that people can't control costs by home-building collectors, storage banks, and plumbing systems: many have done just that.

Solar's biggest problem, I suspect, lies not in the technology or the plumbing hardware cost but rather in the sales pitches of the equipment industry itself, which tries to discourage passive solar and even do-it-yourself applications so it can sell more hardware.

The solar argument, like the electric heat argument, is further confused by the insulation argument, wherein ad' try to compare highly insulated solar or electric buildings with low-insulation traditional-fuel buildings to show some sort of cost advantage.

It's my own view that passive solar, including earth-sheltering, simple glazing, night-curtains, and generous insulation levels, is the most cost-effective way to go. In fact, I've done studies in which simply raising the insulation level of an older electric-heat building reduced heat loss so much that there was no longer a rapid payback to replace the electric heat.

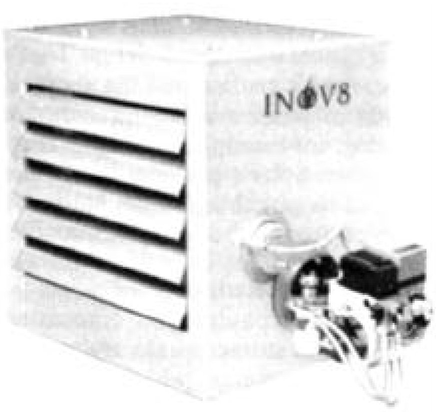


A girl and her horse

Waste oil

Which brings us to another free-fuel system: waste oil. Of course, people have been burning waste oil for years, but in highly inefficient and environmentally destructive ways; now the industry has developed a system for waste-oil combustion which meets all environmental standards. These units are not cheap—about $3,000 each, minimum—and they can't be home made like a sheet-steel wood-stove. Nor are they yet available in the relatively low BTU outputs needed for the typical dwelling: 50,000 BTU or so. But they are available in the 100,000 BTU size; the fuel is free (technically, one is supposed to burn only the waste oil one generates on-premises) and they're as safe as any other appliance bearing the UL label. They can be adapted for hot-water systems, although the vast majority of applications is hot-air. A couple of trade names—Black Gold and Clean-Burn. Here in northern New England most home-owners expect to spend about $4 per square foot to have a contractor put in a more-or-less conventional heating system, and about $.60 per square foot to operate it through the heating season. Some of us spend a lot less than that by investing sweat-equity in both system and fuel; some spend a lot more because they weren't willing to spend for insulation or because they like to wear sheer blouses in December. We used to have a lot more choice in system design, before the banking industry in some areas began telling us how to live; and those who can't escape that sort of control will probably have even less choice in years to come. The nice thing about this country is that most of us can escape; if not with our purchasing patterns or ballots, then with our feet.

(Martin Harris is a Vermont architect, cofounder of "The New England Builder," and author of numerous articles on home building.) Δ



Waste-oil burners such as this model are not yet available in heat capacities small enough for the average house, but they may be a good value anyway. An over-size unit simply works less hard to perform its heating task. They come with the full range of necessary industry and government approvals.

We must all hang together, or assuredly we shall all hang separately.

Benjamin Franklin, July 4, 1776

"To disarm the people is the best and most effectual way to enslave them."

George Mason