Heating Options for a Small Home

A conventional furnace is overkill in a small, well-insulated house. Here are some better options.

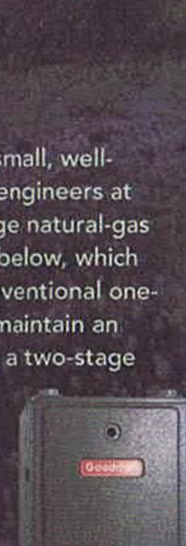
BY MARTIN HOLLADAY

Most U.S. homes are heated with either a boiler (which distributes heat by circulating hot water through tubing) or a furnace (which distributes heat by circulating hot air through ducts). Because new homes often include central air-conditioning, which requires ducts, furnaces have become far more common than boilers.

But houses being built today are much better insulated (and often smaller) than the ones built even a few years ago. Nowadays, a well-insulated, 1200-sq.-ft. house may have a design heat load of only 10,000 to 15,000 Btu/hour, rendering even the smallest

USING A FURNACE ANYWAY

WARY OF EXPERIMENTATION, some builders of small, well-insulated homes still specify a conventional furnace. The engineers at the Building Science Corporation often specify a two-stage natural-gas furnace (for example, the Goodman GMH95-045, shown below, which has an input rating of 40,000 to 115,000 Btu/hour). A conventional one-stage furnace is forced to cycle on and off frequently to maintain an even indoor temperature. The GMH95-045, however, has a two-stage burner and a multispeed blower, so the furnace operates efficiently even under partial-load conditions. The Goodman GMH95-045 is available on the Web for between $839 and $1050.



The main advantages of this approach: Because furnaces are familiar appliances, there's no need for on-site contractor education, and furnaces do a good job distributing heat to remote bedrooms.

The main disadvantage: You'll probably end up with an oversize heating appliance.

available boiler or furnace (50,000 to 80,000 Btu/hour) overkill. Fortunately, there are other options.

Heating with a single point source

One way to lower the cost of your heating system is to heat your house from a single point source rather than using pipes or ducts to distribute heat from an appliance in a mechanical room or basement. This can be done with a woodstove, a pellet stove (see "Is Wood Heat the Answer?" *FHB* #198 and online at FineHomebuilding.com), or a direct-vent space heater.

These solutions work best in compact homes with open floor plans. Of course, the tighter the home's thermal envelope and the thicker the insulation, the more likely indoor temperatures will remain fairly consistent from room to room.

If bedroom doors are kept open during the day, temperatures throughout a small house should be fairly uniform. When doors are closed at night, bedroom temperatures sometimes drift lower; in midwinter, bedroom temperatures may be about 10°F colder than common areas by morning. While such fluctuations are perfectly acceptable to some homeowners, others may balk at the idea of a cool bedroom.

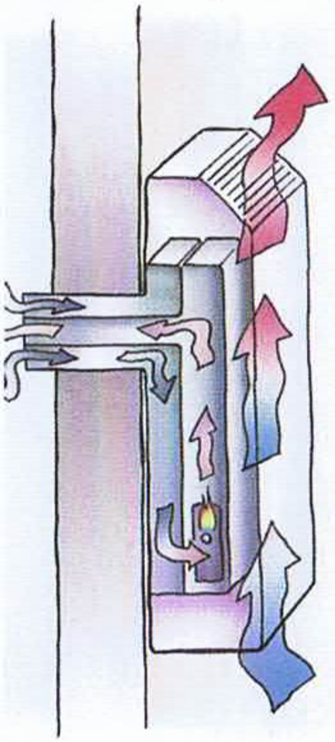
Expensive equipment is overkill

It's worth mentioning two heating options—in-floor radiant systems and ground-source

CASE STUDY ONE **Location: Greenfield, Mass.**

This superinsulated duplex, which is part of Wisdom Way Solar Village, has R-42 walls (12-in. cellulose), R-50 ceilings (14-in. cellulose), and a mixture of double- and triple-pane windows. With a design heat load of 12,000 Btu/hour, each housing unit is heated primarily by a single direct-vent gas space heater on the main floor. A fan in the first-floor ceiling helps to circulate heated air to the second-floor bedrooms, and each full bath has a 500w electric-resistance baseboard heater controlled by a crank timer.

Builder: Rural Development Inc. • **Area:** ranges from 1137 sq. ft. to 1773 sq. ft. (depending on unit)



DIRECT-VENT GAS SPACE HEATERS ARE AFFORDABLE

MANY COMPACT HOMES ARE EASILY HEATED by a direct-vent space heater. Installed on an exterior wall, these suitcase-size heaters require a wall penetration to accommodate two concentric vents. The outer pipe brings in combustion air for the sealed-combustion burner, while the inner pipe is the exhaust flue. It's possible to buy direct-vent heaters that burn natural gas, propane, or kerosene.

One of the biggest benefits of a direct-vent space heater is its low cost. A natural-gas Empire DV215SG heater (15,000 Btu/hour input) can be purchased for $579. Other options include the Rinnai EX11C (8800 Btu/hour output) for about $979 and the Monitor GF1800 (16,000 Btu/hour output) for $1150. If you want a heater that requires no electricity, you might choose the Robur TS2000 (7400 Btu/hour input) for about $500.

The first net-zero-energy house in the country—a superinsulated Habitat for Humanity house in Wheat Ridge, Colo.—is heated with a natural-gas direct-vent space heater in the living room, supplemented by electric-resistance heaters in each bedroom.

ELECTRIC HEAT CAN BE VIABLE

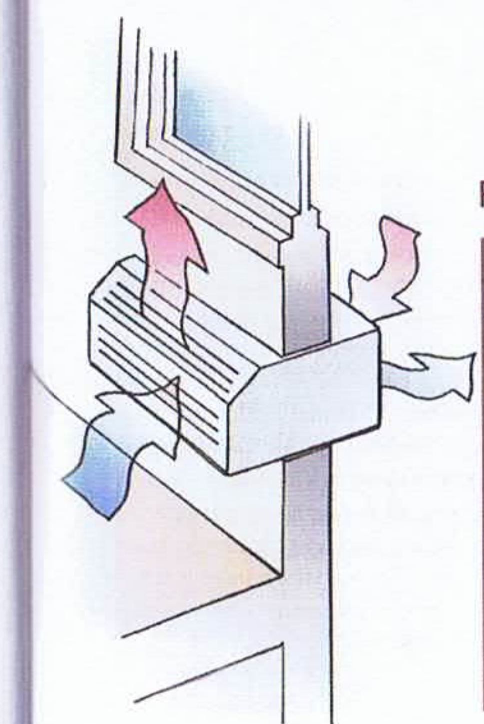
SOME BUILDERS OF NET-ZERO-ENERGY HOMES AVOID GAS AND OIL-FIRED APPLIANCES, preferring to balance energy loads with electricity produced by an on-site photovoltaic array or a wind turbine. Most homes, however, depend on grid-powered electricity. If your local electric utility generates power from fossil fuel, it makes little environmental sense to heat your home with electricity. From a carbon-production standpoint, it's usually better to burn fuels on site rather than in a remote power plant.

Still, heating with electricity can be justified when the home's heating load is extremely low—and when the local utility supplies electricity from a clean source. That's how Katrin Klingenberg, founder of the Passive House Institute US, heats her 1450-sq.-ft. house in Urbana, Ill.

Electric-resistance baseboard heaters cost less to install than any other type of heating system; you can buy a 1500w (4714 Btu/hour) baseboard heater for $90. If your house has a design heat load of 14,000 Btu/hour, you can keep it warm with three modest baseboard heaters ($270, plus installation).

The heating element in an electric baseboard unit works just like the element in a toaster. Any electrician can install these units fairly quickly. The main drawback to this solution is that in most areas of the country, electric-resistance heat is expensive to operate. Still, electricity costs vary widely in the United States, from a low of about 6¢ per kwh to as much as 20¢ per kwh. The lower your electricity cost, the more attractive electric-resistance heating becomes.

Because electric-resistance baseboard heaters are simple to manufacture and inexpensive to purchase, the brand you choose isn't too important. If possible, buy your baseboards from a reputable outlet offering a good warranty.



PTHPs ARE BEST IN MILD CLIMATES

A PACKAGED TERMINAL HEAT PUMP (PTHP) unit is a through-the-wall air-source heat pump. These small, wall-mounted units use electricity to provide both air-conditioning and space heating. Most PTHPs have heat-output ratings in the 6000 Btu/hour to 14,000 Btu/hour range. Although these units are most commonly installed in hotel rooms, a large PTHP can in theory heat a very small or very well-insulated house. The units are inexpensive—generally $740 to $900—and installation is easy. A PTHP needs a hole in the wall and a 20-amp or 30-amp electrical outlet.

Although the low cost of PTHPs makes them attractive, they have a few downsides. Newer models have been engineered to be quieter, but many PTHPs are still noisy to operate. Most also have relatively low efficiencies, especially compared to ductless minisplit units (p. 58). Finally, because most PTHPs switch to resistance heat when the outdoor-air temperature drops to the upper 20s or low 30s, they are better suited to mild climates than cold climates.

Manufacturers include Amana, Friedrich, General Electric, LG, and McQuay International.

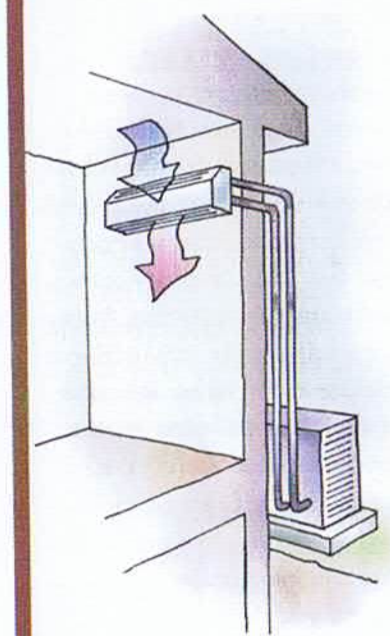
Drawings, except where noted: Dan Thornton. Photos previous page: large, Rob Yagid; inset, courtesy of the manufacturer. Photo this page: courtesy of Rural Development Inc. Photo facing page: courtesy of Paul Norton.

MINISPLITS ARE GAINING POPULARITY, AND FOR GOOD REASON

THE MOST PROMISING HEATING SYSTEM FOR SMALL HOUSES is the ductless minisplit heat pump.

A ductless minisplit is a type of air-source heat pump. Unlike a PTHP, which is all in one package, a ductless minisplit uses two major components. A condenser unit, which sits outside the house, is connected by copper tubing that circulates refrigerant to one or more indoor, wall-mounted blower units. With the proper valves and controls, ductless minisplits can supply space heat as well as cooling.

In recent years, some manufacturers have improved and altered the compressors on these units to improve their heating efficiency significantly. Some ductless minisplits can now be used for heating in very cold climates.



According to energy consultant Marc Rosenbaum, "Minisplits are cheap. They are a packaged system, so they don't require much engineering design, are easy to install, and are a good match for low-load houses with renewable power."

The nominal heat-output rating listed in the specs of a ductless minisplit is calculated at an outdoor temperature of 47°F. The unit's heat output drops with the outdoor temperature, so it's important to check low-temperature performance when choosing a unit.

For example, the Mitsubishi Mr. Slim Hyper-Heat unit (model PUZ-HA36NHA) has a nominal heat-output rating of 38,000 Btu/hour. According to the manufacturer, at an outdoor temperature of –13°F, its heat output drops 21%, to 30,000 Btu/hour. If your heating-design temperature is –13°F, you would assign the unit an output rating of 30,000 Btu/hour, not 38,000 Btu/hour.

Another ductless minisplit, the Quaternity unit from Daikin (model FTXG15HVJU), has a heat-output rating of 17,890 Btu/hour at 43°F. At –4°F, however, its heat output drops to 7310 Btu/hour.

As long as the heating-system designer sizes the unit so that it will meet the building's heat load at the design temperature, there's no reason it won't keep a home comfortable—even when the temperature drops well below zero.

If you're worried that a minisplit heat pump won't be adequate when the thermometer bottoms out in January, remember:

- **The coldest temperature of the year** is reached for only a few hours a year.
- **Tight, superinsulated homes lose heat very slowly,** even during power outages. Unless a cold snap lasts for many days, most superinsulated homes won't lose much heat.
- **In very cold temperatures,** turning off the ventilation system will help a building to stay warm.
- **If you're really worried about prolonged subzero cold snaps,** one or two electric-resistance baseboard units provide cheap insurance.

If you like the idea of a minisplit heat pump but want a ducted system to avoid having fan-coil units in your walls, check out the ducted minisplit units offered by some manufacturers (including Daikin).

heat pumps—that rarely make sense for small homes.

Although in-floor radiant systems are a good way to heat a poorly insulated house, they are overkill and a waste of money in a small, tight house. If your goal is simplicity, there's no reason to invest $12,000 or more on a boiler, one or more circulators, and hundreds of feet of tubing just to supply 15,000 Btu/hour on the coldest day of the year.

If you need only a small amount of space heat, it's equally unwise to invest in a ground-source heat-pump system, which usually costs at least $18,000.

The money required for in-floor radiant piping or a ground-source heat pump would be better invested in improvements to the building envelope—for example, improved air-sealing, more insulation, or high-quality triple-glazed windows. Builders achieving the Passive House standard have demonstrated the many advantages of superinsulation; if your building envelope falls short of Passive House performance levels—and it probably does—then envelope improvements usually make more sense than an investment in expensive heating equipment.

No matter what type of heating equipment you choose, the first step should always be a thorough, accurate calculation of your home's design heat load. Even contractors who do perform a Manual J calculation—a method published by the Air Conditioning Contractors of America (ACCA)—rarely bother to input all the necessary information without fudging and adding unnecessary "safety factors." To avoid the typical result—oversize heating equipment—an accurate heat-loss calculation is essential. □

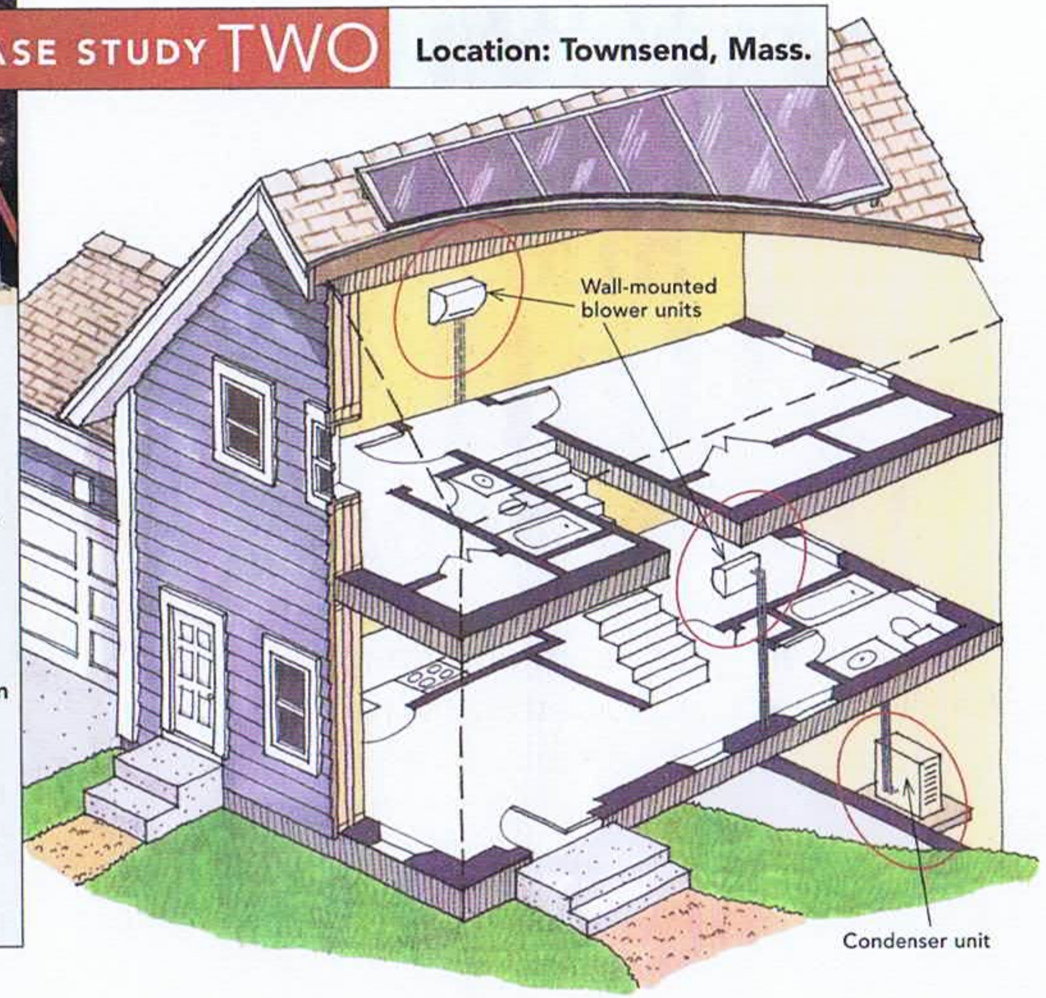
Martin Holladay is a contributing editor.

Top drawing facing page: Martha Garstang Hill. Photos facing page: top, courtesy of Carter Scott; bottom, Justin Fink.

CASE STUDY TWO — Location: Townsend, Mass.

This net-zero-energy house has a design heating load of only 10,500 Btu/hour. The 12-in.-thick R-49 walls are framed with two rows of 2x4s and insulated with 3 in. of closed-cell spray foam and 9 in. of cellulose. The R-75 roof is insulated with 5 in. of closed-cell spray foam and 13 in. of cellulose. All windows are triple-glazed. Heating and cooling is provided by a ductless minisplit system (nominal output of 28,000 Btu/hour). Installed cost of the ductless minisplit system—including one outdoor unit and two indoor units—was $5250.

Builder: R. Carter Scott
Area: 1232 sq. ft.



FOR VERY LIGHT LOADS, CONNECTING A HOT-WATER COIL TO AN ERV IS AN OPTION

IF YOUR HEATING LOAD IS VERY LOW, you might consider heating your house with a hot-water coil in a ventilation duct. First promoted by Passive House builders in Europe, such systems are now being installed by a few cutting-edge builders in the United States.

In a home with a ducted ventilation system incorporating a heat-recovery ventilator (HRV) or an energy-recovery ventilator (ERV), a hot-water coil can be installed downstream from the main fresh-air supply duct. The hot water can be supplied by an ordinary tank-style water heater—not a very efficient heat source, but one that makes sense if your heating load is low.

One ERV manufacturer, Ultimate Air, offers a hot-water coil unit (including a heat-exchange coil, an insulated metal cabinet, a Grundfos circulator, and a control unit) for $936. If the Ultimate Air coil is supplied with 160°F water and 200 cfm of airflow, it can provide 8700 Btu/hour of heat—not much, but enough for a small Passive House.

Full-heat output from the Ultimate Air coil requires 200 cfm of airflow. Because the typical ERV supplies only about 50 cfm of fresh outdoor air, you'll need a second fan that can provide about 150 cfm of recirculated indoor air to the coil. The indoor air needs to be mixed with the ventilation air from the ERV to bring the total airflow across the coil up to 200 cfm.