by Scott Lewis and William Bobenhausen

INTEGRATED HVAC: ONE BOX DOES IT ALL

Combined heating, hot-water, and ventilation systems can pay off in simpler installation and higher efficiency

In the drive for greater economy, simplicity, and efficiency, appliance integration-combining heat, hot water, and ventilation equipment—is becoming an important strategy. There are several reasons why:

- Having separate appliances for each mechanical function is redundant. If one appliance can burn fuel for both space heating and domestic. water heating, for example, then a second burner and venting system can be avoided. This would not only cut down on equipment, it would also reduce energy losses, since each piece of equipment adds to the losses.
- Many new homes have heating loads that are a fraction of those in older homes. Mechanical systems for these "micro-load" homes needn't he as large, as costly, or as complex as in the past. Besides, oversized systems can cause discomfort by moving too much air or causing rapid temperature swings. Combining functions in a single appliance reduces the waste of having several oversized appliances. The combined loads of heating and hot water, taken together, may be a better match for available boilers.
- There is always the desire to simplify construction and perhaps reduce costs—which may be possible if one can reduce the number of appliances that must be installed. Can one "black box" be installed (hopefully by a single trade) to provide our heating, air conditioning, ventilation, and domestic hot water?

In our work, we have seen several levels of appliance integration, from simply combining the hot water and heating functions to complete integration of mechanical functions. All of these attempt to eliminate redundancy and oversizing and increase efficiency.

Heat and Hot Water

Combining hydronic space heating and domestic hot water (DHW) has been routine for many years through the use of tankless coils in boilers. This practice is economical in terms of the installation cost, but can be terribly inefficient during warm weather months, when the entire system is being used for domestic hot water only. An increasingly popular alternative is to use the boiler to heat water in a separate storage tank. Boiler water is circulated through a heat transfer coil in the tank. Once charged with a standby supply of hot water, the boiler sits idle (and cool) rather than maintaining a high, continuous boiler temperature. In addition co higher efficiency, indirect-fired DHW tanks are less likely than tankless coils to foul up with mineral deposits. When water is heated, dissolved minerals precipitate out and form sediment, which accumulates and coats pipe surfaces at the point where they transfer heat to the water. This interferes with heat transfer and constricts the flow of water—common problems with tankless coils. In indirect-fired hot water tanks sediment formation is confined to the outside of the heat exchanger coil where it does not block the flow, and where it can be removed easily. Indirect-fired tanks last longer than the direct-tired-another advantage.

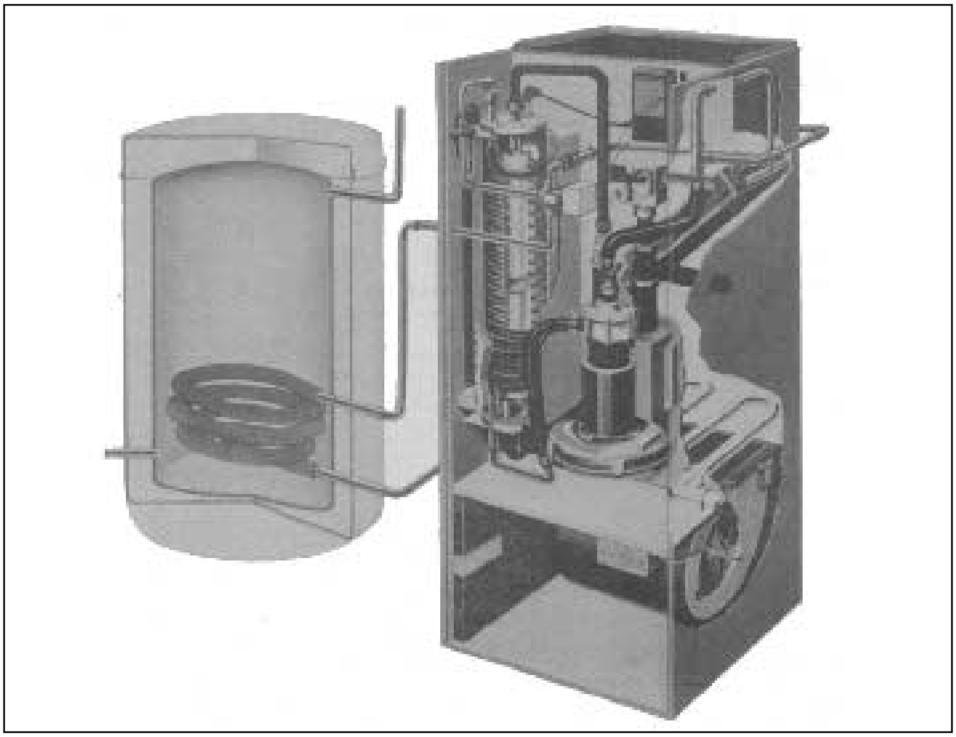
Increasingly, indirect-fired water heater tanks are being installed in conjunction with boilers whose controls automatically transfer heat from the boiler to the DHW tank each time the burner shuts off. But even without this extra "residual-heat-recovery" feature, an indirect-tired DHW tank far surpasses the old tankless coil, improving efficiency during warm weather months by 30 to 50 percent or more when installed correctly.

For homes with warm-air heating systems, domestic hot water has traditionally been handled by a separate appliance-either electric or one with its own burner and vent system. But this is starting to change because of recent developments.

Boiler or Furnace?

Some manufacturers ate producing high-efficiency warm-air furnaces that utilize liquid to cool the heat exchanger, and thereby extract heat from gas-fired burners. The heated liquid then heats room air circulating past a fin-tube heat exchanger. The same liquid can be diverted co a coil inside a separate indirect-fired water heater. This type of "boiler/furnace" or "condensing furnace" is presently available from the Amana and Glowcore Corporations.

The Amana "Energy Command" has been on the market for four years, and the Glowcore "Ultra" for two years. They have annual fuel utilization efficiencies (AFUE) over ninety percent (compared with 75 to 85 percent for more conventional gas-fired furnaces). The higher efficiency is due to the fact that combustion gases are cooled to the point at which water vapor condenses to liquid water rather than escapes up the vent. While most condensing furnaces achieve the additional heat exchange by adding secondary heat



The new UniCore system combines Glowcore's "Ultra" high efficiency furnace (or boiler) with a flameless hot water heater. The system's single burner is located inside the furnace or boiler. In addition to greater efficiencies, the integrated system offers simplified installation: It requires only one through-the-wall PVC went.

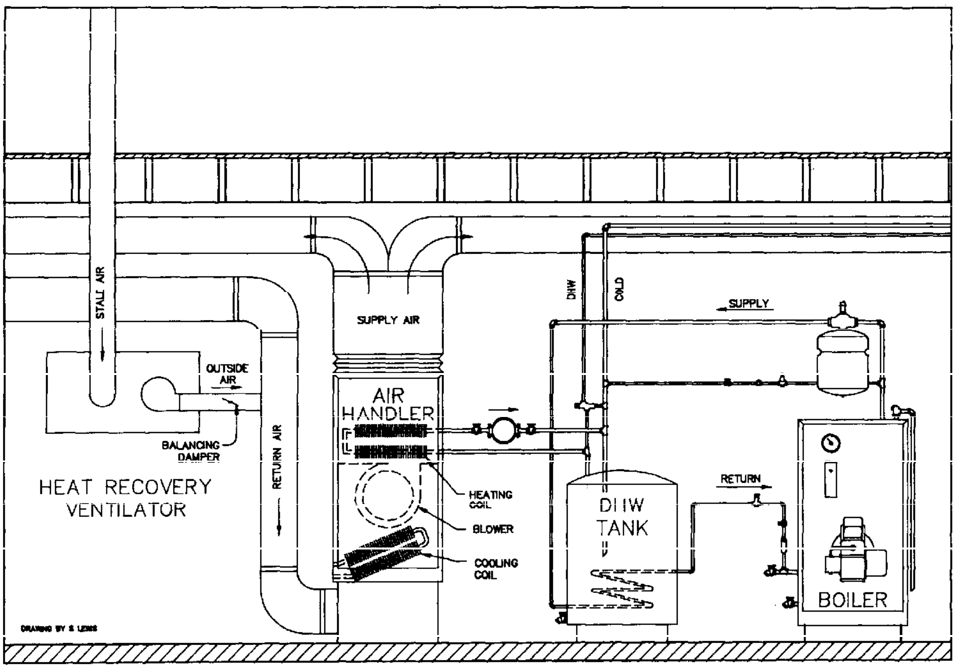


Figure 1. *Hydronic-furnace heating system. In this installation, **a** small, oil-fired boiler heats water in **a** separate DHW tank, and in turn powers a hydronic furnace. Appliance integration needn't look very integrated.*

exchangers, these units employ the more compact liquid-cooled heat exchanger designs.

These models (and condensing furnaces generally) will cost more than conventional gas furnaces. Coupled with an indirect-tired DHW tank, the complete package will cost $1,500 to $1,800 more (installed) than a conventional gas furnace and separate DHW tank. But the extra expense will be rewarded by 10- to 20-percent higher efficiency for heating, still greater improvement in DHW efficiency, and avoidance of a conventional chimney or vent (a 2-inch plastic pipe will do for the exhaust).

Due to the increased cost of condensing furnaces and boilers, some of the best candidates for installation are not micro-load houses at all, but larger, more conventional homes with larger heating loads (60,000 to 120,000 Btus per hour). For such houses, a 10- to 20-percent efficiency improvement may save hundreds of dollars per year. For example, a modest, well-insulated 2,500-square-foot house (R-19 walls, R-30 ceiling, ordinary double glass, tight construction) will have a heat loss factor of about 800 Btus per degree-hour. That translates into a design heat load of about 52,000 Btus per hour and an annual heating load of about 130 million Btus. With a boiler efficiency of 75 percent, the house will cost $1,520 per year to heat with natural gas at $.85 per therm. Using a standard gas-fired domestic hot water heater, the annual cost of heating water will be about $160. The total heating and hot water cost for this base case is about $1,680 per year.

If we increase the efficiency of the boiler to 85 percent and raise the DHW efficiency by 20 percent, the total cost for heat and hot water goes down by about $220 per year. If the high efficiency and indirect-fired hot water tank cost an extra $1,500 to install, that amounts to a 6.9 year "simple payback." This estimate is based on some very conservative assumptions. Similar savings are possible with oil-fired systems when switching from tankless coils to indirect fired hot water tanks.

Hydronic Furnaces

Builders of homes with sharply reduced design heat loads (15,000 to 60,000 Btu's per hour) are discovering that space heating can be treated as a secondary function of the domestic water heater. A number of companies manufacture "hydronic furnaces." These are air handlers that have all of the basic components of a warm-air furnace. But instead of a combustion chamber or electric resistance coils, the source of heat is a fin-tube hot water coil.

Water from a separate boiler or domestic water heater circulates through the air handler to heat room air. These air handlers are also generally supplied with direct expansion cooling coils for summer air conditioning.

Figure 1 illustrates an installation of a small, oil-fired boiler connected to an indirect-fired DHW tank, connected in turn to a hydronic furnace. The hydronic furnace is further connected to an outdoor condenser for summer cooling and a heat-recovery-ventilation system. What makes this an integrated system is that:

- A single burner serves both heating and DHW loads.
- The air handler combines heating, air conditioning, and ventilation in one centrally ducted system, though the heat-recovery-ventilation unit, the condenser (not shown), and the boiler are all external to the air handler itself.

Problems with Ventilation

With the advent of tighter home construction and increased concern about indoor air quality has come the need for central ventilation systems (with or without heat, recovery). For the most part, ventilation systems are currently designed as separate appliances with their own supply and return ductwork. This makes the most sense for retrofit work or for homes with hydronic heating.

But many home builders wish to integrate the ventilation hardware with the heating system to eliminate redundant ductwork and one more thing to think about between framing and drywall application. It is possible to install a ventilation system so that it introduces fresh air directly into the furnace return-air duct. However, there are potential problems with this approach. Referring again to Figure 1, notice that a fixed balancing damper is placed between the heat-recovery-ventilation (HRV) unit and the house return air duct. This is to prevent the negative pressure of the furnace return from drawing in excessive ventilation air.

Another potential problem with connecting the HRV unit to the central system is that the main fan must be operating whenever ventilation is required. This turns out not to cause discomfort as long as the central fan and ductwork is carefully sized to avoid blowing large volumes of air around. Keep in mind that running the fan adds slightly to the electric bill.

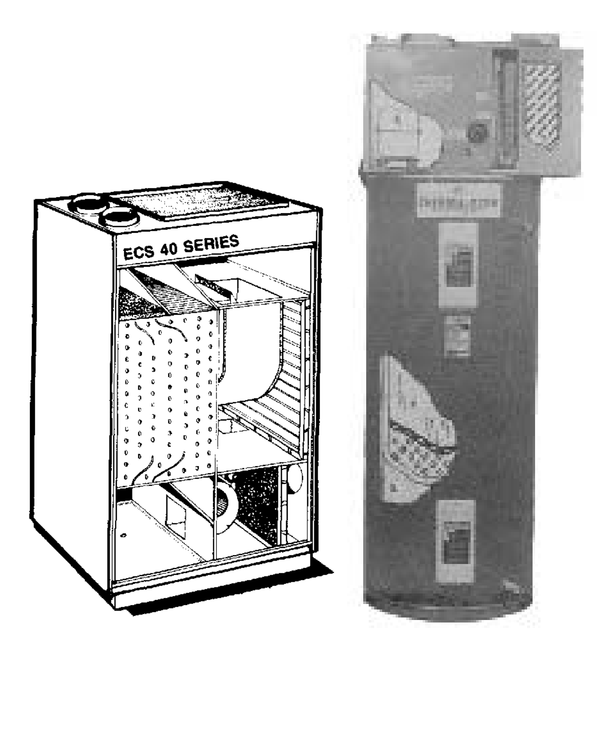
The Black Box

As you may have concluded from the drawing in Figure 1, appliance integration can be achieved thermally and mechanically without looking very integrated. The next step is to pre-engineer and prefabricate the components in a factory to reduce installation costs and complexity. This final development doesn't come easily for several reasons:

- Most manufacturers started out with one type of product (i.e. boilers, furnaces, air conditioners, heat-recovery-ventilators) and haven't much experience with the others.
- Most installers are similarly comfortable with a single mechanical system and are therefore not clamoring for a do-it-all product.
- Building a unitary multi-function appliance means designing something that will not be what every customer wants in terms of features, or what every house requires in every climate in terms of component sizes.

However, there are a few products that do provide multi-function integration in a single unit:

Engineering Development, Inc.'s "Vent-Aire" system combines a heat-recovery-ventilator (also known as an air-to-air heat exchanger) with an air handler and hydronic or electric heating coils. Cooling coils are optional. Hot water for the hydronic coils must still be supplied from a separate DHW



The Vent-Aire ECS Series (Model 40 shown) provides heating, ventilation, and cooling. Therma Vent's Therma-Stor combines ventilation and water heating, with supplemental heating and cooling. Both promise economy and efficiency through integration.

heater or boiler. Stale air is brought to the unit through narrow ducts, and outside air is introduced within the compact 28x50x18-inch Vent-Aire cabinet. A fully equipped unit is typically installed for about $2,500. This product has been out in the field for four years, with the stand-up version out about six months. There was a problem with the original product: Timers failed in approximately 100 units. (The timer regulates a damper that, when open, allows return air to circulate through the unit to prevent frost buildup.) This has been remedied, however, and no further problems have been reported.

The Dec International "Therma-Vent" product is a heat-pump water heater set up to extract heat from ventilation exhaust air during the winter and from incoming fresh air during the summer. It uses a .6 ton (7,200 Btus per hour) compressor to heat water in the tank. If heat isn't needed for the water, refrigerant can circulate through a heating coil or slab floor to help heat the home. Although this product was introduced about 2½ years ago, we understand that the, manufacturer is still making adjustments to it. The 80-gallon Therma-Vent stands 76 inches tall, 24 inches in diameter (a little wider where the compressor is housed at the top). As the Btu figures suggest, the recovery rate is modest without resorting to electric resistance back-up. Hence, the large volume. Cost is about $1,800 installed.

Advanced Mechanical Technology, Inc. (AMTI), with research funds from the Gas Research Institute, has been developing a unit which promises to combine a condensing furnace with a liquid-cooled heat transfer module, a hot water tank, and a cooling/compressor/condenser all in one box. But don't expect this unit to be marketed for at least another year. A great deal of research has gone into this product, but it seems the company is extremely cautious about actually trying it in the field.

Summary

It's hard to estimate what kind of market penetration has been achieved with these innovative products or system designs. Although none are even close to common use, indirect-fired DHW tanks are fairly popular, and condensing furnaces are becoming more so. The other items, particularly the "black box" systems, are still at the cutting edge, and at this point have appeal only to the extremely sophisticated consumer.

Unfortunately, it is still true that the average homeowner is not interested in investing in energy efficiency, and will only look at first cost even if it means tremendous inefficiencies. But the conscientious builder should offer integrated appliances in cases where the "simple payback" is attractive. The greater comfort these streamlined appliances bring will result in less complaints and callbacks. ■

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FOR PRODUCT INFORMATION:

Condensing Furnaces

Energy Command
Amana Refrigeration, Inc.
Amana, IA 52204
319/622-5511

Ultra
Glowcore Heating & Cooling
P.O. Box 8971
Cleveland, OH 44136
216/273-4040

Fully Integrated Appliances

Therma-Vent
Therma-Stor Products Group
Dec International
P.O. Box 8050
Madison, WI 53708
608/222-3484

Triple Integrated Appliance
Advanced Mechanical Technology, Inc.
141 California St.
Newton, MA 02158
617/964-2042

Vent-Aire
Engineering Development Inc.
4850 Northpark Dr.
Colorado Springs, CO 80907
719/599-9080

Hydronic Furnaces

Apollo Hydro Heat System
State Industries
3216 Wellington Court
Ashland City, TN 37015
615/792-4371

Fireless Furnace Hydronic Furnace
Fireless Furnace, Inc.
623 S. East St.
Anaheim, CA 92805
714/533-7370

Hydronic Furnace Systems
First Co. *
8273 Moberly Ln.
Dallas, TX 75227
214/388-5751
*also manufactures units sold under the Mor-Flo Industries' Polaris brand name.

Indirect-Fired Domestic Hot Water Tanks

Aqua-Coil
Ford Products Corp.
Ford Products Road
Valley Cottage, NY 10989

Aquas-Mite
Carlin Co./Subsidiary of Ford
601 Marshall Phelps Rd.
P.O. Box 750
Windsor, CT 06095
203/683-2272

Aqua-Stor
Ener-Quip Inc.
99 East Kansas St.
Hackensack, NJ 07601
609/728-1700

Boiler Twin
Arrow Heating Equipment
1703 E. Main St.
Torrington, CT 06790
203/482-7723

Calo-bloc (storage and exchanger)
Werit Thermal N.A.
155 Webster St.
Hanover, MA 02339
617/633-7287

Hotstow
Vaughn Manufacturing Corp.
386 Box 5431
Salishury, MA 01950
617/462-6683

Hot Water Maker
Amtrol, Inc.
1400 Division Rd.
West Warwick, RI 02893
401/884-6300

Maxitank
Belcher New England
222 Lee Burbank Hwy.
Revere, MA 02151
617/284-4490

Phase III
Triangle Tube & Specialty Co.
Thomas Ave. RD #5
Box 122-J
Williamstown, NJ 08094
609/728-1700