THE FUTURE OF SPACE HEATING IS A VERY EFFICIENT WATER HEATER

As space heating loads shrink, most of the identified barriers are not strictly technical. We need new test methods, new codes and we need manufacturers and contractors to look beyond their normal boundaries.

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SPECIAL TO CONTRACTOR

How many days a year that you are at home do you use hot water? (Generally, all of them.) How many days a year that you are home do you heat your house? (Generally, not all of them.) How many days a year that you are home do you cool your house? (Generally, not all of them.)

So why are we so focused on increasing the efficiency of space conditioning (heating and cooling) when we use hot water practically every day of the year? Why do we install condensing furnaces but standard efficiency water heaters?

How we got here

Let's go back about 35 years to just after the first oil crisis and look at the energy pie for our dwellings. The single largest portion of the pie was energy needed for space conditioning, which for most of the U.S. meant heating. Why? At that time, houses were relatively drafty, there was practically no thermal insulation, windows were single glazed and the efficiency of our heating equipment was rather low. Most homes did not have central air conditioning and window air conditioners were the exception, not the rule! In most climates heating was the largest energy use, in some cooling, but in most places the combined space conditioning needs were clearly number one.

In the intervening years, contractors, building science practitioners and utility and government programs have focused on improving the thermal efficiency of our dwellings and increasing the efficiency of devices that heat and cool them. We have added insulation to and reduced uncontrolled infiltration of existing dwelling units; we have installed higher performance windows; and we have upgraded the efficiency of the heating and cooling equipment. Building standards are in effect that make these features the norm in most climate zones.

At that time, refrigeration was probably the second largest portion of the pie. Remember in the 1970s when automatic defrost was a new feature for refrigerators? At that time, both heating and cooling were operated simultaneously! California established a standard for refrigerators in the late 1970s followed by the Federal government several years later. Today, the same size refrigerator uses roughly one-third the energy, and unless you have

The Eternal Condensing Hybrid features a stainless steel heat exchanger with a built in 2-gal. reserve tank and meets NSF Standards.

more than one refrigerator in your home, it has fallen to less than the third largest portion of the household energy pie.

Back then water heating was the third largest portion of the energy pie. The gas-, oil- or propane-fired water heating equipment had thermal efficiencies of approximately 75%, but the standby losses were quite large due to minimal insulation around the tanks. Electric water heaters had thermal efficiencies of approximately 98%, but again the tanks had minimal insulation and standby losses were large. There were few if any tankless water heaters. Overall, the equipment was not particularly efficient. At the time, the average U.S. household had just over three people.

In the intervening years, we have done relatively little to make significant improvements to the efficiency of water heating. Federal standards were established for the efficiency of residential scale water heaters: energy factors now provide one number to compare the combination of thermal efficiency and standby losses. Thermal efficiency has not changed much for either atmospheric fossil fuel-fired water heaters or for electric water heaters: the improvement in efficiency has come from reducing the standby losses, primarily through better insulation. We also established Federal standards for the flow rates of showers and faucets and we have a variety of programs, including Energy Star, to incent the use of low water consuming dishwashers and washing machines.

Granted, these changes have reduced the need for hot water and lowered the standby losses of the water heaters we use, but the change in efficiency compared to the changes we made to space conditioning is small. In addition, the number of people per household has dropped to just under three people. Over the past 30 years, the net effect is that water heating has risen as a percentage of our energy use. It is now number two in most northern climates and it is number one in most of the southern climates. For example, water heating represents almost 50% of the natural gas use of households in Los Angeles and San Diego while space heating represents about 35%.

Rheem Water Heating has expanded its line of hybrid heat pump water heaters with a new 40-gal. model.

Most practitioners and the manufacturers who supply them products are touting higher R-values, better U-values, lower infiltration rates and higher AFUEs, HSPFs, SEERs and EERs, but seem to be ignoring the fact that water heating is now larger than space conditioning in much of the country.

How big is hot water?

We already mentioned that annual water heating energy can be larger than space heating in many climates. Now let's look at the peak need for space heating compared to that for water heating. All over the country, whether in retrofits or in new construction, we are seeing buildings need less than 10 Btuh per square foot for their peak heating and cooling loads. This means that a 2,000-sq.ft. house would have a peak heating load of 20,000 Btuh; a 3,000-sq.ft. house would have a peak heating load of 30,000 Btuh, etc. The U.S. median home is about 2,500-sq.ft. This means that the majority of us live in homes which, if built correctly in accordance with current energy codes or retrofitted in accordance with current home performance practices, need less than 40,000 Btuh peak for heating.

Now, I know that not so long ago, it was very common to install an 80,000 or 120,000 Btuh furnace in median and smaller houses, but as we tighten them up, these furnaces are significantly oversized. In addition, I have not seen very many condensing furnaces with less than 40,000 Btuh inputs, have you? This means that we are continuing to significantly oversize space heating equipment compared to the loads of the thermally efficient dwellings in which they are installed.

It gets even more problematic when

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we realize that furnaces are sized at the 97th or 99th percentile, so that they should run practically full time on the coldest days of the year. How many hours of how many days do these peak conditions occur? Not very many. This means that part-load conditions occur most of the heating season. In thermally efficient homes, we can anticipate that the majority of the hours will be at less than half of the peak and many at around one quarter of the peak load. This means we should be very concerned about the part-load efficiency of the heating equipment we install, but of course, the rating method for efficiency is focused on the peak capabilities.

Now let's look at water heating. To keep up with 2 GPM at a temperature rise of 70ºF (incoming cold water at 50 ºF and the water heater at 120ºF) takes between 77,000 Btuh (90% thermal efficiency) and 92,000 Btuh (75% thermal efficiency). If the water is heated electrically, a bit more than 20 kW is needed to accomplish the same task. This flow rate is roughly the hot water

The NEXT Hybrid from A. O. Smith has a tankless engine and a small buffer tank.

portion of a 2.5 GPM legal maximum flow showerhead.

While certainly not a peak hot water flow rate, it is an event that occurs in a large number of households on a daily basis. According to research that has been conducted over many years, it is rare to see much more than 3 GPM to 4 GPM of hot water being required at any one time. When it does, the duration is relatively short, and this peak condition can be met with a relatively small storage tank.

Many of us still think that we need a larger tank to accommodate peak conditions, given that burner inputs are fixed and relatively small. With the advent of modern whole-house tankless water heaters, we have been told that tanks are not necessary, only modulating burners (or elements) with the upper-end capacity to handle the peaks. It turns out there is another way to accomplish one of the functions that customers want — "never run out of hot water in my 'getting ready for work' shower." Why not have a tank of some modest size and a burner (or element) large enough to keep up with the heating need for one shower? The tank provides for the overlaps that result in peak flow rates and volumes. It also provides for small amounts of heating, particularly at low-flow rates, so that the burner does not need to fire or modulate down that low. To provide for the level of "continuousness" described above, the burner needs a capacity in the range of 80,000 to 120,000 Btuh (or 20-30 kW).

In any event, even using the smaller number for the energy needed to keep up with one shower, the peak needed for water heating is more than twice

Heat Transfer Products' Phoenix Evolution incorporates a modulating condensing water heater and a module that draws heat from the water for use in space heating applications.

as large of the peak needed for space heating. And this occurs every day of the year!

One thermal engine

Most of you who have hydronic heating systems already have the solution we are discussing — a combined water heating and space heating system. What this article has been making the case for is to install combined systems in homes with air-based heating (and cooling) systems. In fact, there are many thousands of these combi systems installed throughout the U.S. They have been field engineered by plumbing and heating professionals using standard efficiency heating equipment and air handlers (some with air conditioners) with and without ECM fan motors to obtain better part load performance. Given the shift to more thermally efficient dwellings and the need for hot water every day of the year, it makes sense to install very high-efficiency water heating and heat the house as a byproduct of the water heating system.

We seem to know how to do this with boiler-based fossil-fired equipment, but the emphasis seems to still be on space heating. How about looking at water heating technology as the basis of the equipment?

There are now several condensing gas-fired water heaters that can do the job. Most are storage water heaters (34-gal. to 100-gal.) with larger burners (100,000 to 199,000 Btuh). Some burners have fixed input rates; others have modest amounts of modulation (3:1 turndown ratios). There is at least one gas tankless water heater that incorporates a roughly 2-gal. tank and a 15:1 turndown ratio that should be up to the job. There is even a unit that includes a heat recovery ventilator in an integrated water heating, space heating, ventilation package.

It is possible to use electrically based technology for the same task. An electric storage water heater combined with a tankless electric booster heater is one alternative. The storage tank can have either a resistance element or a heat pump as the primary means of heating the tank. Another alternative is to use heat pump space conditioning technology with a zone dedicated to water heating. Geothermal heat pump manufacturers have done this for some time, generally using a desuperheater to preheat the water during periods when the home is being cooled. We are beginning to see some air source heat pump manufacturers bringing similar ideas to the U.S. market.

So what's the catch?

The concept behind this article was discussed at the 2010 Emerging Technology Symposium sponsored by the International Association of Plumbing and Mechanical Officials and at the 2010 Hot Water Forum sponsored by the American Council for an Energy-Efficient Economy, both of which were held in Ontario, Calif., during May.

The idea of the water heating as the primary focus of the thermal engine made sense to both audiences. Both wondered why such a sensible idea had not gained much market share.

Several barriers were identified:

•The HVAC industry (manufacturers and contractors) needs to change its thinking regarding the primacy of space heating.

•The water heating industry (manufacturers and contractors) needs to change its thinking regarding the lowly status of water heating.

•Currently combi systems need to be field engineered. If significant market share is to be obtained, pre-engineered systems (heaters, pumps, air handlers and controls) need to be supplied by manufacturers. The range of sizes needs to be matched to much smaller space heating loads than has been the norm.

•There is no recognized test procedure to rate the performance of combi systems. The Canadians are planning to release CSA P.9 for public review and comment in the next few months. The focus needs to be on high performance at part load conditions.

•A performance label is needed that can communicate the benefits of well-engineered combi systems.

•There is a lack of field verification of the performance and benefits of high thermal efficiency combi systems. There is evidence from studies in Canada that to get the performance and efficiency gains expected from condensing water heating technology, it is essential that the return water temperature be low enough to ensure that the burner will fire in condensing mode.

•Air conditioners are not generally AHRI listed with air handlers (only with furnaces) and default SEER/EER values must be used in compliance calculations when matching equipment listings are not available.

•Building codes and the related compliance software and energy performance programs and the related software need to incorporate the performance benefits of high-efficiency combi systems.

•Lines of responsibility between plumbing and HVAC contractors are not clear. In some cases, it appears that they don't want to talk with each other.

What to do

Clearly, we need to make sure that high-efficiency combi systems perform properly. We need engineering to ensure more replicable installations that will be easier to operate and maintain.

However, as with many seemingly technical issues, most of the identified barriers are not strictly technical. We need test methods so they can be compared with each other and with current mainstream water heating and space conditioning systems. We need to change codes and programs to accommodate the technology, and we need manufacturers and contractors to look beyond their normal boundaries to help create a more effective future.

Next year I hope to write a follow-up article documenting the advances this technical niche has made. In short: Innovate! Innovate! Innovate! C

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