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Water Heating: Nuts and Bolts of New Technologies (along with ramblings and musings on where we came from, where we're going and how it all might fit together)

We live in a high tech world. This technology allows us to do things kings of old couldn't even dream of. Cell phones allow the "Occupy" movement and "flash mobs" to coordinate in ways those old kings might have found scary. We can fly to the other side of the world or simply talk with people there pretty easily. Technology though has its downs along with the ups. All the cell phones in a given area can be turned off if an authority feels threatened and who actually knows how to get in there and fix a chip? I understand all of the new, high performance water heating technologies rely on chips.

I'm not really that worried about it and am not suggesting we need to give up on jets, cars and computers in favor of non-electronic horse powered carriages, sail powered boats and stone tablets. I am going to propose there is a balance to be found between desired results and complexity. It often is called Elegant Simplicity. More on that later.

Every water heater once it's installed is part of a system. That's an obvious-ism! Have you ever attempted to measure "system efficiency"? From what I know, most folks haven't seriously considered it. Jim Lutz of Lawrence Berkeley Labs has. Hot water system efficiency can be measured in two ways; energy efficiency and water efficiency. I come from the arid west where we fight ugly political battles over water rights and have done so for at least four generations. In his work measuring showers Jim has found that the average waste of water is 30% and the average waste of energy is 41% though the worst is nearly 70%. Hmmm, that just about wipes out the energy benefit from installing that new efficient water heater!

This pushes up to look at the whole hot water system; hot water maker, distribution and fixtures before coming to any conclusions about what measures to take in order to save energy. Beyond energy and water savings it might make sense to think about how the hot water system affects the rest of the house. Are there safety or comfort concerns? Are we chilling the living space in winter with a heat pump water heater? Are we corroding away cast iron sewer lines with condensate from our efficient gas water heater? Is the owner going to be able to deal with the equipment? What happens when he doesn't? If you have doubts the equipment will be properly maintained, don't install it. This happened quite a lot with solar water heating over twenty years ago and it helped give the industry a black eye that hasn't completely healed, even now. Also, if the nifty equipment is only going to serve one frugal individual, who showers once a week, there is little likelihood it will ever make sense from either a "return on investment" or "life cycle cost" point of view.

There is a loading order when thinking about upgrading. No point in putting an expensive, high tech heater into an old rusty steel system that hardly delivers water. That old rusty system could

be replaced with small PEX piping and a demand system or a central core system if the plumbing runs aren't long. Once that's done and insulated, so it wastes only a few cups of water before hot arrives at the frugal fixtures, it's time to look at the heat maker. Also, you don't want to do work that gets in the way of doing more or better work later on. No point in sealing the duct-work if hydronic heating is in the future. Or, don't insulate the attic before air sealing.

Water heating is a fast changing field. Electric heat pump heaters are getting a lot of attention. Condensing gas tank and tankless heaters are gaining in performance and market share. We need to understand these technologies, when they are appropriate and when they aren't.

Heat pump water heaters have actually been around for decades, but for various economic and technical reasons never really caught on. Now that energy is expensive both in dollars and other ways, we have stronger reasons to look at utilizing the energy we have, better. Modern heat pumps perform at a coefficient of performance (COP) of around two, more or less. Theoretically it's possible to get a COP of at least four. As the heat pump (HP) world is changing, we are likely to see more changes like ducted heat pumps and gas powered heat pumps. If you had a standard HP unit and a ducted unit, would you install them differently? Of course! For the ducted unit, you would be considering where in the house dehumidification and cooling would be best appreciated. You would be looking at where you would prefer to pull heat from. I imagine ducting will allow many more choices.

Heat pump technology heats water much more slowly than electric resistance heating. This means you want a bigger tank and you don't want multiple large loads, because the unit won't be able to keep up in heat pump mode alone. See how some sort of tempered or preheated water would be a great fit with heat pumps? When electric water heaters were new in the world and only had 800 or 1000 watt elements, it was commonly suggested you install a “tempering tank” ahead of it, (in a warm place) to preheat the water. This would reduce complaints about the electric heater not being able to keep up with demand.

For now we have basically three choices in where to install heat pumps. These are attic, garage/basement and conditioned space. Although there is plenty of overlap, each has it's own things to bear in mind.

Attic

- Tanks are heavy! Can the structure carry the load?
- Plumbing leaks. Is that leak coming through the living room ceiling or is there a pan ?
- Attics can get very hot and cold. Some heat pumps can't run in too much heat or work efficiently if it's too cold.
- Is noise from the unit going to resonate into the bedroom? How will you prevent it?
- Attics can be cramped. Is there enough working room? Will the filter regularly get cleaned up there?
- Is the attic big enough? Heat pumps need 750 to 1000 cubic feet of air to work right.
- If earthquakes are a concern, what will you brace the tank to?
- On the plus side, there is often lots of hot air in the attic which will boost heat pump performance as long as it's not too hot. Check with the manufacturer.

Garage/basement

- Space for the heater can be valuable.
- Can the garage (particularly) get too cold for the HP to work?
- How is condensate going to be disposed of? This could get difficult!
- Will the unit be breathing clean, dust free air?
- A plus, particularly for basements is dehumidification.

Conditioned space

- Where will it go? Remember it needs lots of air.
- Will it work against the existing heating/cooling system?
- How will noise be dealt with?
- Condensate removal? A condensate pump can be added, but it's one more thing to go wrong.
- In hot climates the cooling provided could be a real plus.

For all heat pump locations, two big potential problems are limited air flow and dirty air filters. In a research project done recently by Southern Company of fifty heat pump installations, these were the two biggest problems. Improper heater placement can limit intake or discharge air flow. Dirty filter also translates to poor air flow and lower COP. Cleaning an air filter ***sounds*** like such a simple thing, but it seems to be a real problem. One more reason to keep things simple where possible. This leads us to owner/user education. If a unit you put in misbehaves or shuts down because the owner failed to perform basic maintenance, guess where the blame will land? It'll all be your fault for pushing bad equipment! Avoid that scenario by educating the owner and making sure they know what maintenance needs to be done and giving them resources for dealing with problems.

Everything just said about owner education with heat pumps applies equally to condensing technologies. Nobody wants to make or receive that call on Christmas morning about having no hot water.

Condensing heaters come in tank or tankless although the dividing line is a bit unclear. The concept has been around well over a hundred years although not by the present name. There were contact and non-contact heaters. Contact heaters actually mingled together flame (or hot products of combustion) and the water to be heated. Old heaters claimed to get up to 92% of the heat! These were used for tub or sink water heating where water simply flowed unpressurized through the heater and out to be used. Non-contact heaters had to be somewhat less efficient as they heated through metal. I like these old heaters because they were simple, and worked for years, efficiently. They relied on things like gravity, water pressure and the properties of materials to work. These are pretty reliable forces! Designs like these can demonstrate “elegant simplicity”, which looks and acts simple but can be surprisingly difficult to arrive at. The rewards for really good design will continue long after a messy design has been turned to scrap, shipped overseas and returned to us as a new car. Not all old design makes the cut. Some designers thought gas could be burned so the products of combustion were healthy and should be kept indoors!

New heaters clearly can perform even better than old, but maintenance is needed to hold onto that high efficiency. Water quality plays into it in a big way as about 85% of the US has hard water and even a thin film of scale on a heat exchanger can both cut efficiency and shorten the heat exchanger's life, from overheating. Tank type heaters and tankless react differently to scale formation, with it generally being more of a problem in tankless heaters. The higher the rate of heat transfer, the more of a concern hard water becomes. One just needs to read the warranties carefully!

Condensing heaters can be installed lots of places, but venting carries many rules with it, trying to keep fumes out of homes and people. This cuts down the number of possible locations. Also with fan assisted venting, noise is a real concern. The “Vent Attenuation Assembly” (eg: Vertex) is a PVC device that looks and acts like a muffler, to quiet down fan noise. It goes in the exhaust vent and has a condensate drain port.

Avoid installing heaters where service will be difficult, or where they will be be exposed to extremes in temperature, moisture or dust. It's always good when you feel pressed into doing something that you know will be a pain in the neck for the next guy, to imagine you're the next guy! When you go to a home and say out loud, “What was that guy thinking?”, you don't ever want the homeowner to say, “Well, you installed it.”

Condensing heaters are NOT a direct replacement for conventional heaters. I just had a case where the installer followed the instructions, hooked up the heater to a 3/4” gas line and didn't know why it wasn't performing as it should. Turned out he ran a lot of 1/2” line to supply the 3/4” line. Good gas line up-sizing, surge protected power, condensate neutralization and disposal, dedicated plastic venting and possibly air supply for combustion are all things yesterday's heater didn't need.

One particularly appropriate use for heat pump or condensing heaters is in snug, low energy load homes. Direct venting or zero combustion appliances help insure cleaner air in a tight home. Also, the heating load may be low enough that likely the condensing equipment and possibly the heat pump could be used to deal with it. This does seem to be where we're headed, equipment-wise. We'll have a single appliance that does heating, cooling, water heating, ventilation and who knows... maybe even refrigeration. Combining these allows for simpler installation and the ability to scavenge heat or coolth from one process to help another. Now if we could just fit a TV into the mix, everybody would want one!

Parting words from a different talk: *Although I’ve mentioned a number of technical considerations for combined systems, the biggest difficulties lie with plumber and end user education and expectations. Keeping a plumber on tap somewhere near the design lab couldn’t hurt either. Unless those needs are dealt with, getting good systems installed will remain the exception.*

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Resources:

Affordable Comfort Inc. www.affordablecomfort.org

American Council for an Energy Efficient Economy www.ACEEE.org

Chris Gray of Southern Company http://www.aceee.org/files/pdf/conferences/hwf/2011/5A%20-%20Chris%20Gray.pdf

Gary Klein http://www.aceee.org/files/pdf/conferences/hwf/2011/Plenary%20-%20Gary%20Klein.pdf

Heating Help www.heatinghelp.com

Home Energy Magazine www.homeenergy.org

Home Power Magazine www.homepower.com

National Assn. of Corrosion Engineers www.nace.org

Water Heater Rescue www.waterheaterrescue.com

Manufacturers:	www.	Heat pump	condensing
AO Smith	http://www.hotwater.com/water-heaters/	yes	yes
AirGenerate	http://www.airgenerate.com/products.php	yes	
American	http://www.americanwaterheater.com/	yes	yes
Bradford White	http://www.bradfordwhite.com/products/		yes
Grand Hall	http://www.eternalwaterheater.com/		yes
GE	http://www.geappliances.com/heat-pump-hot-water-heater/	yes	
Heat Transfer Products	http://www.htproducts.com/	yes	yes
Navien	http://www.navienamerica.com/		yes
Rheem	http://www.rheem.com/Products/tank_water_heaters/	yes	yes
Rinnai	http://www.rinnai.us/tankless-water-heater/		yes
Steibel Eltron	http://www.stiebel-eltron-usa.com/accelera.html	yes	
Takagi	http://www.takagi.com/		yes
USI Green Energy	http://www.usigreenenergy.com/products.htm	yes	