Air Source Heat Pumps; They Cool, Too

Systems Are Gaining Popularity, But Beware of The Down Side

Unlikely as it seems, that cold Vermont winter air that many of us devote time and money trying to keep out of our homes can actually be a heating source under the right circumstances.

No, you don't want to throw your windows open, but the technology exists to extract warmth from that air using a refrigerant, increase it through compression, and use it to boost your indoor heat. This mechanism is called an air source heat pump (ASHP).

Capturing heat from the air and moving it somewhere else is basically the same thing a refrigerator does; the fridge extracts heat from the air inside your unit to keep your food cold, while the ASHP harvests heat from the outdoors, even in very cold weather, and moves it inside. Adding to the appeal of these ASHP systems is that with a flick of a switch they can change direction, extracting warmth from inside your home and transferring it to the outside.

Ta-da! Air conditioning.

So there's a lot to like about these systems, not least being that they transfer heat without combusting fossil fuels or wood, and therefore release no emissions (at least directly).

But there are reasons to be wary of them as well, and Washington Electric Co-op members need to know about these and evaluate their situation before making the leap to this technology. Air source heat pumps installed in homes that are not well weatherized – where the insulation is no better than adequate and where the sealing around joints, plumbing, vents, etc., is imperfect – can increase your utility bill significantly.

"Air source heat pumps are run by electricity," explains Bill Powell, Washington Electric's director of products and services (and resident "energy coach"). "If your home has low or average thermal performance (high fuel use, high air infiltration, low insulation) they're going to be coming on a lot. In some cases we've seen dramatic increases in people's electric bills after the heat pump was installed.

"If this were South Carolina it would be different," he notes. "It's not so demanding to raise the indoor temperature to 70 degrees when you're starting from 45 degrees outside, but when you're starting from 10 degrees or less it's a very heavy lift for these units."

The heat they transfer is not directly comparable to the gross output from a combustion system – a furnace or boiler. Air source heat pumps typically are sized as a single outside unit (the compressor) and multiple internal units delivering warm air to each room. Their effectiveness, Powell says, decreases significantly when the thermometer dips below zero. Except in exceptionally well-constructed houses, an ASHP system cannot be expected to replace conventional heating in Vermont. Their role should only be to supplement the existing system.

Yet air source heat pumps are not always marketed that way. Some utilities are promoting them without sufficient cautions about their limitations, and there's become an active market for leasing heat pumps. The systems are readily installed in existing homes, and people typically purchase or lease more than one unit, placing them in strategic locations in the home. That they produce virtually no emissions adds to their appeal, as does the fact that they can double as air conditioners in the warmer months.

Washington Electric Co-op installed an ASHP system in its office building as part of the renovations made necessary by the May 2011 flood. But those renovations included, first and foremost, extensive improvements to the building's thermal envelope.

"There needs to be a superior level of thermal performance before ASHP makes sense," Powell reiterates. "That's our message to our members."

And it's followed by another message.

"If the energy-usage increase that we've seen – in places that weren't well-suited to air source heat pumps – were to become widespread among our membership, it could be a challenge for WEC to meet that demand without, potentially, costly new investments in our electric system. Actually, that could be an issue not just for WEC, but for utilities throughout the state."

Still, under the right conditions, ASHP has a lot to offer. And those conditions can and do exist in Vermont.

"Deep retrofit"

Paul Sipple and Joan Rae own New England Construction Company (NECCO) in Waitsfield. Their home is in Fayston, and they are Washington Electric Cooperative members. NECCO specializes in construction and renovations for municipalities and schools. Their other specialty is roofing. For the most part, residential construction and renovation is outside the NECCO box.

But Paul's interest in roofing led to a more general interest in insulation and energy conservation and the technologies for achieving the best results. Expecting a slowdown in 2009, the company bought an abandoned and foreclosed two-story, wood-frame house at auction in Waterbury. Paul saw it as an opportunity to try out some of the retrofitting techniques he'd been studying. Progress was stop-and-go as NECCO picked up contracting work at the state office complex after Tropical Storm Irene, but slowly the little house on Railroad Street came together.

Paul and his crew aimed for nothing shy of what's called a "deep energy retrofit," converting what started out as a perhaps substandard building into what ENERGY STAR calls a "high performance home." They added more space in the wall cavities, not by expanding inwardly, because the rooms were already pretty small, but by moving out the exterior walls; they removed the entire basement floor, shoveled out an extra eight inches of dirt, and added three inches of insulation and a vapor barrier. When all was done the insulation for the walls above grade was R-35, the roof R-65, the basement walls R-30, and the basement floor R-15.

"It's a very well-insulated house," says Sipple, "not to the degree of a PassivHaus, certainly, but way more than is commonly done."

When the renovations were complete, except for interior painting and finishing touches, a heating-demand calculation was performed that revealed that an air source heat pump, by itself, would meet the need. "The house does not have a secondary heating system," says Paul.

The heat pump has two components: a compressor seated on a platform attached to the house outside, and a unit in the doorway alcove that circulates and re-warms the air inside. They are connected by piping that circulates a refrigerant (which is not Freon but performs in a similar way.)

There's one problem with a building this tight, Paul explains. For health and safety reasons, you need an air-exchanging system, removing the CO_2 and other impurities and importing clean outdoor air. Problem: the outdoor air (much of the time) in Waterbury, Vermont, is cold. But heat recovery ventilators like the one Paul Sipple installed in the basement use a system whereby the indoor air that's being expelled, and the outdoor air being imported, thread past each other in a tight network of tubes; in doing so the indoor air passes its most of its warmth to the new air entering the building.

Sipple has even added an extra step in this air-exchange process: a closed loop that circulates warm fluid between an area in the insulated basement floor and the air entranceway. This way, the incoming air is mildly preheated by the time it goes into the exchanger. These steps give the air a little temperature boost, making the work of the heat pump outside a bit easier.

"It's important to remember that the heat pump and the air exchanger are two completely different systems," Sipple emphasizes. "The heat pump deals only with conditioning interior air."

In a high-performance house the activities of the inhabitants, their body heat, and everything else that generates energy stays within the house and adds to the overall warmth.

"The more you cook, the more you run the dryer, the more sources of heat, the better off you are," says Sipple.

But there can be a problem if you're relying on ASHP.

"The unit will work down to minus-18° F (outdoor temperature), and then, even if it's still calling for heat, it will automatically shut off. After a certain amount of time it will come back on, but soon it will shut off again. So it's the least effective starting at minus 18."

But this is an airtight house, remember?

"A house like this doesn't lose much heat, unless people are going in and out, in and out. If the system were off for 24 hours, like if the electricity went off, the temperature inside would probably only drop 10 degrees."

Above: Just inside the doorway at the Waterbury house, a unit mounted on the wall uses air warmed and transferred from outside to boost the temperature of the indoor air. Below: Sipple complemented the heat-pump system with an air exchanger in the basement, which introduces the fresh air that's necessary for a healthy environment in a super-insulated house.

NECCO and Paul Sipple have demonstrated that you can retrofit a Vermont wood-frame house to "deep energy" standards. It was not cheap (the heat recovery ventilation, says Sipple, cost $6,000, and the heat pump a surprisingly less $1,200). But some future resident will benefit from a home that uses no fossil fuel, and – assuming things go according to plan – will be warmed with an air source heat pump without exorbitant electricity costs. And cooled during the summer.

Because the house is tight. Tight as the proverbial tick.

Passivhaus: the German import

Washington Electric Co-op member Chris Miksic, of Montpelier Construction, declares, "There's a Passive House Revolution going on around here."

And he must be right, because a Passive House Alliance has recently been formed in this state. Vermont builders and at least some of their customers are known for their passion for efficiency and conservation, and Passive House brings those values to their apex.

Passivhaus (the original German spelling) refers to buildings, residential and otherwise, designed to meet rigorous standards both for energy efficiency and low energy usage. For homes and buildings this well and tightly constructed, air source heat pumps as the sole source of heating and cooling are more than satisfactory.

Montpelier Construction, working in conjunction with Certified Passive House Consultant (CPHC) Indigo Ruth-Davis of Calais, recently completed a project in Middlesex known as the Whitchurch Passive House Cottage.

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