It’s Air Conditioning, Not Air Cool-ditioning

Tight homes need dehumidification more than cooling, and SEER ratings should recognize latent as well as sensible cooling

 By Michael Chandler | April 12, 2011

This 640-square-foot cabin with radiant floor and spray foam insulation hardly needs any cooling, but it needs dehumidification provided by the 11,700 BTU/h vertical PTHP that fits in the bottom of the display cabinet. At 10.7 SEER, its doesn't meet code minimums despite the efficiency of the envelope. A little unit like this would be perfect for a number of superinsulated situations, except it's illegal.

“Why should anyone bother to ‘right-size’ an air conditioner — especially when it costs $350 to hire an engineer to ensure that the Manual J and Manual D calculations are performed properly?”

The reason I always pay a third-party engineer, not employed by my HVAC contractor, to do accurate load calculations is because my mixed-humid climate here in NC makes it very critical to get the sizing right in order to enhance dehumidification. As we build smaller, better and tighter envelopes, especially with exterior shading, it becomes increasingly difficult to size equipment small enough to run long enough to remove the latent heat (moisture) without removing too much sensible heat (over-cooling). The result far too often is a well designed envelope with summer humidity and air quality issues.

Right sizing generally doesn’t save money; a larger unit on the same duct system will actually cost only slightly more than a right-sized unit, and the cost of hiring the engineer to calculate the load and CFM per room for a tight, well-insulated and shaded, passive solar home may wipe out that savings. But on any given day, the right-sized equipment will run longer and thus dehumidify much more efficiently.

It’s tough to find a small, efficient, ducted air conditioner

Unfortunately, it can be difficult to find affordable, very small ducted central air conditioners (less than 2 tons cooling) with high energy-efficiency ratings, and it’s really a struggle to convince building inspectors to allow us to use simulated performance offsets to permit low-performing equipment in homes with a really great building envelope. In air conditioning we compare equipment by EER and SEER ratings. The code minimum where I live is 13 SEER (14 for Energy Star), but I can’t buy a ducted AC smaller than 2 tons that meets that standard.

In the past, we’ve responded by installing variable-speed and zoned-bypass HVAC solutions with longer, more complex duct systems to allow us to combine zones to use larger 2-3 ton equipment with higher SEER ratings. But even very well-designed complex duct systems are much more prone to installer error than simple duct systems with

multiple air handlers. So we end up using much more expensive ductless minisplits hung on the walls (which incidentally have overly complex wireless thermostats that our clients have to hide away from kids and guests).

The problem with EER and SEER ratings

The larger issue in my mind is the fact that code-minimum SEER ratings are calculated to prioritize sensible cooling and disregard latent cooling (dehumidification).

The Energy Efficiency Ratios (EER) of a cooling system (AC or heat pump) is calculated by comparing the sensible cooling ability with the electricity consumed on a BTU per Watt-hour basis. One BTU is the amount of energy (252 heat calories) needed to change the temperature of a pound of water one degree Fahrenheit.

One ton of cooling is defined as 12,000 BTU/h. (Don't ask me for metric equivalents, please.) If a cooling system supplies 12,000 BTU/h of cooling capacity while consuming 1,000 watts of power, it is rated as a 12 EER system (12,000 / 1,000 = 12 EER.)

SEER ratings are set by NAECA, a Federal Regulatory Agency independent of the code authorities, and are intended to represent cooling efficiency over the course of a cooling season. These measurements only take sensible cooling into consideration. Minimum HVAC efficiencies are set by the code by SEER ratings, not EER ratings. It takes energy — 1,000 BTU per pint — to remove moisture from the air. But if that energy doesn't contribute to changing the temperature of the air, it is excluded from the SEER ratings.

As Alex Wilson mentioned in his earlier piece, the industry has responded by providing equipment that cools air with less dehumidification. That way the units get higher SEER ratings — a way to be competitive in the marketplace.

A one-ton unit (12,000 BTU/h sensible) which is dehumidifying at 3 pints/hr is using 3,300 BTU/h latent for dehumidification and is removing 15,300 BTUs in combined sensible and latent heat. If it is consuming 1,000 watts, then it's actually removing 15,300 BTUs

combined sensible and latent for an effective EER of 15.3. But in this example the rated SEER is still 12 and fails to meet the minimum code standard.

So if the house I'm building is well enough insulated it may be illegal to install the right sized equipment as the smaller equipment isn't available in the necessary efficiency unless you use variable speed to reduce the capacity of oversized ducted equipment or use minisplit units, both of which are much more expensive solutions than smaller ducted equipment that would actually be sized correctly. My clients often go to great lengths to avoid using the AC by opening windows or setting the thermostat at a very warm setting, so we are forced to install very expensive equipment that may be used for three or four weeks per year, despite the fact that these homes are HERS 50 already without the fancy equipment.

Technical solutions to boost latent capacity

There are some manufacturers who have built equipment that can dry air without cooling it very much. One way to do this is to use a "run around coil" where a heat exchange coil in the return air line upstream of the air handler is connected to a coil in the supply manifold downstream (and typically above) the air handler. The cooled air leaving the unit cools the fluid in the exit "re-heat" coil which drops to the intake "pre-cool" coil and pre-cools the air entering the unit. This results in warmer air returning to the house and a longer run time, with resultant increased dehumidification.

A more efficient way to do this, called "sub-cool reheat," is to divert the warm liquid refrigerant from the outside compressor and pass it through the re-heat coil on its way to the air handler. This warms the exit air but also pre-cools the refrigerant and improves the performance of the air conditioner. Either of these add air resistance at the second coil and increase energy usage at the blower, resulting in a lower EER as well as a MUCH lower SEER.

Yet another way is to install a valve that can divert some of the expanded gas to a compressor that actively heats the re-heat coil in the same way a conventional dehumidifier would and sends some of it

to an outdoor compressor where it is cooled in the fashion of a conventional heat-pump. This is how the Daikin minisplits work.

Adding run-around coils or the valves and controls to manage sub-cool reheat is expensive and, since it's not reflected in the SEER rating, is pretty much reserved for larger capacity high-end equipment. If the SEER standard could take the combined latent and sensible BTUs into account, manufacturers would be more motivated to produce equipment that would offer better dehumidification at all sizes.

Smart thermostats can be set to lower the setting if they sense a high humidity condition in the house. If the owners set it to 80 degrees and the humidity rises above 60%, the thermostat can reset itself to 75 degrees until the humidity is reduced. But our customers are so proud of their energy-efficient homes that they gleefully report that the "turned their AC off almost all summer" and added significant risk of mildew and indoor air problems.

Small is more important than efficient when the envelope is done right

Designers of small, super-insulated buildings in mixed-humid and hot-humid climates may choose to prioritize right-sized equipment over high SEER equipment, largely due to the fact that advanced dehumidification is just not marketable in the smaller tonnage sizes that are appropriate for the small demand buildings. The minisplit systems that have these capabilities in small capacity sizes are very expensive and may be seen as unsightly and overly complex by many clients. (Our clients think they are ugly and hate the multi-function wireless remote thermostats).

On our very small (840-1,100 sq. ft.) buildings with radiant floor heating, we've been using a 10.7 EER GE ducted vertical Packaged Terminal Heat Pump (PTHP) unit (Zone-Line AZ75H12DAC for $1,454 delivered — see photo), which gives 11,700 BTU/h cooling and 3.6 pts/hr (3,960 BTU/h) dehumidification for 1,093 watts and can supplement the radiant floor heat if necessary with a 3.3 COP. The unit can be easily installed in a 24″x24″x32″ space. It's a great, if

somewhat noisy, dehumidification solution for affordable, small, very well insulated homes in a mixed-humid zone.

With the code minimum now at 13 SEER and Energy Star at 14, it's very hard to get equipment sized small enough for the load without serious energy modeling and offset negotiations with the inspectors. If energy efficiency ratings could give credit for the dehumidification capacity as well as the sensible cooling capacity, it would give incentives for manufacturers to offer equipment in all sizes and price ranges with better dehumidification. As I understand it, Amana's ActivDry PTAC is currently withdrawn from the market largely due to this issue.

The affordable gut remodel we are building now hits a projected HERS 59 by REM/Rate (8.5% better than code by REScheck) with 8,330 BTU/h sensible and 1,204 latent. We can choose to forgo air conditioning all together, but if we want a 2-ton, 14 SEER unit to meet Energy Star, we'll be oversized by a factor of two at significant cost and even with variable speed will be likely to run into humidity issues, regardless of how little or how much the owners actually use it.

Code minimums are ever increasing, and 16 SEER seems not far away, perhaps a new class of dehumidifiers or through-wall mini AC units recently proposed by James Morgan will lead the way. It would be fun for the Americans to be leading the pack again.