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Why Right-Size?

Science versus Practicality

Why Do We Oversize Heating and Cooling Systems?

HVAC contractors tend to oversize to account for those few instances of high occupancy or extreme weather. In other cases, it is to account for anticipated poor quality in the construction of the home or even their poorly installed distribution systems. For the most part, it is to avoid callbacks that eat into the bottom line of a profitable business. There is a perception that as long as the temperature set-points are met within a home, regardless of the circumstances, a homeowner will be satisfied. I don't entirely blame contractors for this, because I have heard enough homeowners complain when a hand thermometer differs from their thermostat by a degree or two. This homeowner mentality that their home must be able to maintain their perceived ideal conditions 100% of the time regardless of the outdoor environment is naïve, especially when they aren't spending the money required to even come close to achieving those goals.

Regardless of why systems are oversized, the question still remains "Should they be oversized?" Most contractors will still say yes, but if you ask anyone, 90°F in Florida is not the same as 90°F in Arizona. The difference…humidity.

Why Right-Size?

If you have been to any conference on energy efficiency or green construction, the phrase "build tight, ventilate right" is familiar. The intention is to minimize building loads while maintaining indoor air quality. As residential building science techniques and industry products progress over the years, the home has become less tolerant of errors during construction[1]. Because these homes are built air tight, appropriate exhaust ventilation is needed to remove internal sources of moisture (showers, cooking, and breathing) and an additional mechanical system is needed to assist in the dehumidification process during the summer and swing months. This is commonly accomplished by running the cooling system, even though dehumidification is more of a by-product of cooling.

The purpose of right-sizing is to match the actual load and to optimize the performance of the cooling system to best maintain the desired indoor conditions. This doesn't just refer to maintaining the proper temperature within a home; it also refers to the ability to maintain humidity within an acceptable range. If temperature was the only consideration in sizing a cooling system, right-sizing would help extend the life expectancy of the equipment by avoiding short-cycling of the compressor and the first cost for the unit will be lower due to a smaller system capacity being required. In addition, the longer run time of the cooling system helps maintain temperature throughout the house and help minimize stratification.

From a comfort and durability aspect, the latent capacity (ability to remove moisture) is the key for why systems should be right-sized. In most homes, the central cooling system is the sole source of dehumidification (unless a stand-alone dehumidifier is also used). So unless the system is running, humidity levels within the home go unchecked. Right-sizing allows for the

[1] Lstiburek, Joseph W. "5 Fundamental Changes In the Last 50 Years." ASHRAE Journal July 2009: p52-56

system to run for longer periods of time. This provides time for moisture to condense on the evaporator coil and drain away. Studies have shown that occupants are more agreeable to a higher summer temperature set-point when the relative humidity is lower in the home. So to remove moisture, we need the air-conditioner running. This will help keep the relative humidity levels within the home below the range where mold and mildew can become an issue. The smaller system running for a longer period ends up in many cases using less or the same amount of energy as it is more efficient and requires a lower wattage draw.

If the system is oversized, it will quickly meet the sensible cooling requirements (temperature) and will not run for a significant enough time to allow the condensate to drain off of the evaporator coil. In many cases, the condensate on the evaporator coil will evaporate back into the airstream as the fan continues for a few minutes at the end of the cooling cycle.

Right-Sized or Under-Sized?

Right-sizing isn't a new concept. John Proctor, managing partner of Proctor Engineering Group, wrote "Bigger is Not Better – Sizing Air Conditioners Properly" back in 1995. Still there will always be those in the HVAC industry that believe right-sizing is actually under-sizing or that it is an energy efficiency measure that disregards comfort. Building America's goal has always been to minimize energy consumption while maintaining or improving comfort and durability. When incorporated into a whole-building systems approach to home construction, right-sizing is an effective method. I will say that again, right-sizing only works in a *whole-building systems approach*.

This is not to say that issues can not arise when right-sizing a home's HVAC equipment. Right-sizing only works if quality control is maintained throughout the construction process. If the home is significantly leakier or building specifications change drastically from design, the HVAC design needs to be modified as well. In the majority of cases, it is not that your system is under-sized, it is that your home was not built to the design specifications.

What's the Alternative?

Many HVAC contractors still use tonnage per square feet rules-of-thumb for their climate region. These rules of thumbs are based on older construction practices and even new code built homes would likely be oversized based on this method. So you have oversized the cooling system based on the peak cooling design temperature, but how often is the home seeing those peak ambient conditions throughout the year. Remember, there is no other dehumidifying equipment in most homes. So in the spring and fall, when humidity can be high but temperatures are moderate, how do you lower indoor relative humidity?

In an attempt to address humidity issues, many manufacturers are offering thermostats with humidity control that try to maximize the latent removal capacity of air conditioning systems. These systems typically will drop the temperature set-point by 2 degrees to force the cooling system to operate. The unit will run at a lower fan speed to allow more condensing on the evaporator coil. Once the lower temperature set-point has been met, the system shuts off and allows the temperature to naturally rise again. Once it is back to the normal set-point, it will repeat this cycle. This is an improvement, but it requires a thermidistat and a variable speed air handler. If oversized, this system will quickly reach that 2 degrees of cooling and shut off without significantly removing moisture.

Hopefully the rational for right-sizing systems is becoming clear. On those hottest hours of the year, the cooling system may only be able to cool down to a couple degrees above your design indoor temperature, but it will better address moisture control for the rest of the year. And on those hottest hours, again, overall comfort will still be maintained as occupants react more adversely to humidity than temperature.

Is My System Right-Sized?

To learn how to right-size an HVAC system, refer to CARB's Forced-Air HVAC Design Guide.

Now comes the tricky part, is your system right-sized or not? To be honest, there is no way to tell until the house is built and it is nearly impossible to fix once it has been built. Ductwork is sized according to the required CFM of air and the Btu load for each room. It may be easy enough to switch out the air handler if incorrectly sized, but to switch out the ductwork is typically not feasible.

Who is Responsible if the System Doesn't Work?

If it can be shown that an error was made during the design calculations, it is the responsibility of the HVAC designer. But in most cases, when issues arise about insufficient heating or cooling, it is a result of failures during construction which result in the design conditions not being met. In this case, it is not the HVAC designer's liability. All the HVAC designer is doing is implementing a national recognized methodology for right-sizing ductwork, ACCA's Manual J/S/D/T. It is the responsibility of the general contractor to ensure that quality control is maintained throughout the construction process and that the as-built home matches the building specifications and drawings.

What to look for in an HVAC contractor?

When searching for an HVAC contractor, the bid request should require at a minimum, Manual J and S calculations to be completed prior to purchase of equipment. A Manual D duct design is also highly recommended. If a contractor is either unfamiliar or unwilling to do these calculations, it is better to look elsewhere for a contractor, regardless of how low that contractor's bid may be. If a contractor is not willing to design the system based on the best available method in the industry, what makes you believe that they are knowledgeable enough to provide a quality installation? Excessive capacity, low airflow, high duct leakage, and improper refrigerant charge can easily lead to your system running at 70% efficiency or worse, so choosing a qualified contractor is very important.

Many contractors often say they don't do Manual J calculations, because of the bidding process. Simple, it takes too long. When an HVAC contractor is called to quote a job, the client typically wants a quote by the end of the meeting or within a day at the latest. This doesn't give an HVAC contractor the ability to right-size a system for their quote. Also, this is a lot of analysis to be completed without a guarantee of getting the work. It is recommended that the homeowner/builder get an estimate based on the HVAC contractors experience or preferred rule-of-thumb, but make sure that the final system installed is based on (and priced according to) Manual J/S/D calculations. The initial estimate is likely to be oversized, so the final pricing should be lower for the overall system, though the cost of the system design needs to be accounted for.

The contract should also require the HVAC contractor to provide a Certificate of Product Ratings from the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) for the heating and cooling systems and proof of proper refrigerant charge of the air-conditioning system (super-heat, sub-cooling, or by weight). They should also provide proof of refrigerant handling certification, as this is required of all technicians.

Does the contractor utilize/recommend a variable speed air handler? A variable speed air handler should be specified for any new installation as these will provide energy savings over standard single-speed air handlers, and more importantly, can improve the ability of the system to dehumidify. Variable speed air handlers also allow the contractor to make proper adjustments to the system air flow. Inadequate air flow issues can result in a 5% or more reduction in the potential performance of these systems.[2]

It is also recommended that HVAC contractors agree to provide their services in compliance with ACCA's Quality Installation Specification (https://www.acca.org/Files/?id=116). This is an ANSI-approved standard that describes precisely the steps a contractor must take to ensure a quality HVAC installation.

In the end, the homeowner/builder gets what they pay for. It is their responsibility to demand this level of effort and see the importance of this design step. Make sure that a HVAC contractor is certified, knowledgeable of the latest right-sizing methodology, and willing to duct seal.

For more information or comments, contact Srikanth Puttagunta at sri@swinter.com

[2] Parker, Danny "Right-Sizing Heating And Cooling Equipment." July 2001