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Why should you consider an independent HVAC design service?

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When building a new home, the owner should be aware of the consequences of a poorly sized and installed HVAC system. This article describes the common errors made by HVAC contractors and the effects this has on the home's occupants.

For the purposes of this discussion we are considering heat pump technology. It has been our experience that in 98% of the systems we have designed, heat pump systems have provided the lowest cost to operate.

For climates without extended periods of sub-freezing temperatures, heat pumps are an excellent energy-efficient alternative to furnaces and air conditioners. Similar to a refrigerator, a heat pump uses electricity (or natural gas) to move heat from a cool space into warm space. During the heating season, heat pumps move heat from the cool outdoors into your warm house; during the cooling season, heat pumps move heat from your cool house into the warmer outdoors. Because they move heat rather than generate heat, heat pumps can provide up to four times the amount of energy they consume.

If you heat with electricity, a heat pump can trim usage by as much as 30 to 40 percent. High efficiency 2 stage heat pumps with variable speed air handlers can also dehumidify better than standard single capacity units, resulting in less energy usage and more cooling comfort in summer.

Heating and cooling systems come in many different capacities in order to meet the needs of different sized

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homes. But there's a common misunderstanding that you can choose from a variety of different sizes depending on your preferences and budget, and that a bigger air conditioner (higher ton capacity) will be better for your home. The truth is that every home should be matched with a heating/cooling system of a specific size and installing HVAC equipment that's too large can lead to serious negative consequences.

When building a new home, the owners rely on their builder to hire and manage the various subcontractors. When it comes to the HVAC system there is very little involvement by the owner. Most owners don't know that the mechanical codes require the HVAC contractor to provide a load analysis. The load analysis is used to ensure that the HVAC system is sized properly. This means that the heating and cooling components are not oversized by more than 15% (applies to the Southeast), or 25% in colder climates.

Accurate load calculations aren't just a good idea; they are required by most building codes. In the 2012 IRC, the requirement can be found in Section M1401.3: "Heating and cooling equipment and appliances shall be sized in

accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methodologies."

Even though contractors are supposed to show a local code official proof that a load calculation was performed, enforcement of this requirement is spotty. Code officials collect the load calculations but they don't know how to assess them.

In violation of the mechanical codes, the vast majority of residential HVAC systems are not sized using the proper analysis tools. Instead the industry uses "rule of thumb" system designs. This results in poor indoor air quality, high energy bills, shorter equipment life and occupant health issues.

The obvious question is; what about the fact that the HVAC systems "pass Inspection"? Passing inspection dose not equal code compliance. Yes, you read that correctly; code inspection officials rely on the licensed HVAC contractor to size the equipment correctly.

The budget for building a new home is a critical part of the process. Owners expect their builders to give them an accurate cost to build the house and detail the cost components.

There's a problem though. How is it possible to provide an estimated cost for the HVAC system when the major factors to heat gain/loss like windows and doors haven't been selected. The windows and doors can account for 30% of the heating and cooling load of the home. Yet, we see time and again that budgets for HVAC are set before any load calculations could have been performed.

Then there's the issue of where to run the duct work. How does the HVAC contractor know how to price the duct work if they haven't done a duct design? Yet again they set a budget based on a rule of thumb and make it fit later. The owner ends up with a spider network of flex duct, with crimped sections that restrict air flow, duct runs that are too long and air distribution problems that are very costly to fix.

Offering a budget for the HVAC system before doing the code required analysis and design sets a false expectation in the owner's mind and ultimately the HVAC contractor has to do whatever they can to get the HVAC system installed for the budget. This results in corners being cut and poor quality installations.

Most HVAC Systems Oversized

Even though there are many problems with oversized HVAC systems (as you'll see below), they can still be found in most homes. The problem can almost always be traced back to a contractor doing the installation without performing the code required load calculations. In 40 years of designing indoor environmental systems SED has never seen a correctly designed HVAC system, or a code compliant heating and cooling load analysis.

Thermal Envelope

New technology in home building results in a "tight thermal envelope". This includes better insulation, air sealing, high-performance windows, and improved duct systems, all of which dramatically reduce cooling loads. As a result, smaller HVAC units can usually be installed assuming that a correct load analysis has been done.

While all of these improvements in the thermal envelope increase efficiency, and reduce the energy a home needs for heating and cooling; it results in less air flow in the home. That's because the amount of air the HVAC system can move is tied to the size of the HVAC equipment, or tonnage. This results in poor indoor air quality, improper dehumidification and wide temperature differences from room to room.

Why are HVAC Systems Oversized?

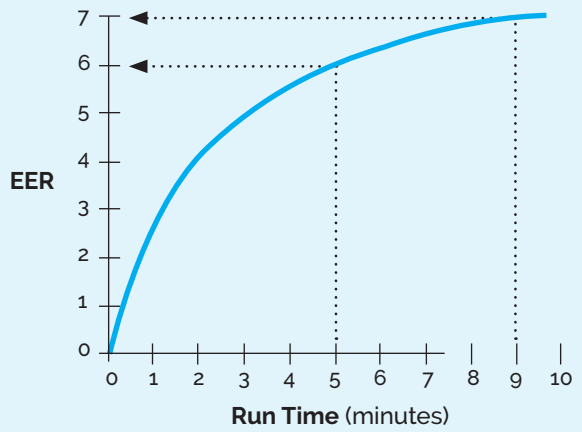
It is common for contractors to install oversized HVAC equipment and/or more units than are needed, because the contractors know that the home needs more air flow and the only way to achieve the air flow is with more HVAC equipment. Another common justification for oversized HVAC systems is that they provide cooling more quickly, thus avoiding any chance of not meeting the cooling demand.

Bigger is Not Better

When it comes to HVAC systems, bigger is not better. Oversized HVAC systems "short-cycle" or run for shorter periods of time. The efficiency of HVAC equipment is low when they first start and increases gradually, reaching peak efficiency in about 10 minutes. As shown in Figure 1 below, when operating time increases from 5 to 9 minutes, efficiency improves 17 percent. In this example, the energy efficiency ratio (EER) increases from 6 to 7. In addition, bursts

of cold air from oversized units can trick the thermostats into shutting off the system before the whole house is cool. Moreover, short operation times do not allow the system to effectively remove humidity with serious repercussions to occupant health, comfort and equipment durability.

FIGURE 1: EFFICIENCY VERSUS RUN TIME



Air Distribution System – Duct Design

Air leakage and heat losses from ducts can rob your space conditioning system of its capacity under peak conditions. In many residential air conditioning systems, the duct system passes through unconditioned zones, which can decrease the system efficiency. Cooling systems can easily lose 30 percent of their peak sensible capacity from this heat gain alone.

Duct leakage can produce even larger impacts. Supply leaks can lose highly conditioned air and depressurize your home, adding more infiltration. Return leaks can add to the air conditioner or furnace loads and draw air from unintended locations. All these issues add up to a strong case for having the duct system properly sealed and placed within the conditioned space.

A well-designed system will include duct sealing and testing as part of installing a new air conditioning system. In new construction, seriously consider installing the duct system inside the insulated building envelope. This will both reduce space conditioning energy use and improve comfort by reducing the time it takes the indoor temperature to reach the thermostat set-point.

Improved comfort

Correctly sized HVAC systems supply conditioned air at a lower volume and over a longer period of time than oversized units. This allows the conditioned air to gradually mix into the space and reduces cold drafts near the supply registers. In addition, right-sized systems provide better dehumidification. These features maintain a more consistent level of comfort throughout a house.

Improved Dehumidification

Air conditioners don't just cool your home down, they also reduce humidity levels. But an air conditioner can only remove moisture from the air while it is operating. Because oversized air conditioners have such short cooling cycles, they don't operate for long enough periods to adequately dehumidify your home.

In order for air conditioners to dehumidify or dry the air, they have to cycle long enough for moisture to condense on the coils and drain away. With oversized units, short-cycling reduces the amount of condensation that drains off the coils and even allows some moisture to evaporate back into the air. Air that is not properly dehumidified can be uncomfortable and promotes the growth of mold and mildew indoors.

Quieter Systems

Correctly sized HVAC systems deliver smaller volumes of air over longer periods of time. This reduces indoor noise caused when conditioned air moves through ducts and registers at high speeds and when systems frequently start and stop. In addition, correctly sized systems require smaller compressor and fan motors which reduce indoor and outdoor noise when these components are operating.

Energy Cost

Energy consumption increases with the size of the capacity of the HVAC equipment and decreases when the system is properly designed. Short-cycling prevents the HVAC equipment from operating at peak efficiency.

HVAC equipment uses up the most energy while they are starting up and shutting down, and the least amount of energy while they are in the middle of a heating/cooling cycle. Because an oversized HVAC systems cooling cycles

are so short, they spend most of their time in the parts of the cooling cycles that use up the most energy, which leads to high utility bills. In addition, larger HVAC equipment costs more, so the owner ends up spending extra money up-front on a system that will actually end up costing more to operate.

Indoor Air Quality, IAQ

There's more to providing for indoor comfort than installing HVAC equipment. Indoor air quality is the single biggest contributor to your health and comfort. Air filtration and purification should be included, but will not be effective unless the HVAC duct system is properly installed and sealed to eliminate contamination. The HVAC system for your home should not be used during construction! Only when the home is in move in condition should the HVAC system be started up. Conditioning systems can become contaminated with construction dust if they are used to condition the space to acclimate the hardwoods and other final trim work. The construction dust in the duct system is a breeding ground for mold when combined with moisture from sweeting ducts; caused by an oversized cooling system.

Occupant Health

Not sizing HVAC systems can be expensive, but the real cost is the effect it has on occupant health. Oversized equipment leads to excess cooling capacity leads to condensation in the duct work. In addition, most systems have dust introduced when the HVAC system is used during the final stages of construction; when flooring and woodwork dust is prevalent. The combination of moisture and cellulous dust is a perfect breeding ground for MOLD.

A major consideration for your home's environmental system is the supply of fresh air. Because the thermal envelope of newer homes is getting increasingly tighter (less outdoor air infiltration) the home requires that fresh air be added. This is done by piping in outdoor air into the HVAC dust system. A properly designed system should include an energy recovery ventilator, ERV. The ERV will transfer the energy in the stale exhaust air and transfer to the incoming fresh air. This results in not "shocking" the system with hot air in the summer and cold air in the winter. An ERV must be designed for the correct amount of fresh air based on the home's occupancy.

HVAC Equipment Reliability

Air conditioners do the most amount of work while they are starting up and shutting down. An oversized air conditioner goes through many more cooling cycles throughout the day than a properly sized air conditioner does, which means an oversized system will undergo a whole lot of stress that can eventually lead to breakdowns.

Short-cycling increases wear and tear. Other maintenance problems, such as dirty filters, leaky ducts, and improper refrigerant charge, are masked by the large output of oversized units. These problems can increase the amount and magnitude of maintenance required by air conditioners and possibly shorten their lives. Since correctly designed HVAC systems do not short-cycle, these maintenance costs are reduced and other maintenance requirements can be more apparent and more likely to be corrected in a timely manner.

How Can You Know Your Home's HVAC System is Correctly designed?

There is a lot that goes into the design of a home's environmental system. In the vast majority of instances an accurate load calculation is passed over due to time and cost.

The result is that the homeowner pays the price in higher utility bills, comfort issues and diminished indoor air quality. The right design for your home's environmental system, including the HVAC system, requires that an independent expert do the load analysis and air distribution design.

This ensures that you have a non-biased assessment of your home's needs for heating, cooling, fresh air ventilation, insulation, and air filtration/purification.

At Scientific Environmental Design, we have been designing indoor environmental systems for over 38 years. We have saved our clients $100 million dollars in energy cost over that time and delivered clean, healthy and comfortable interior living spaces with the highest indoor air quality available from any source on the market today.

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