Sizing Residential Heating and Air Conditioning Systems

The correct sizing of residential heating and air conditioning systems is crucial to ensuring proper indoor space conditioning, equipment performance and economical operation. Unfortunately, homeowners too often measure "correct sizing" by the system's ability to meet any indoor thermostat setting at any outdoor temperature. While desirable during extreme conditions, this method of sizing is not practical or effective for the vast majority of time. Heating and cooling systems must be sized to meet typical or average indoor and outdoor conditions to ensure proper mixing, filtration and dehumidification of indoor air from season to season and year to year.

To select the "proper size" heating and air conditioning system for a home, five factors must be considered:

1. Insulating value
2. Air leakage/air infiltration rate
3. Solar orientation
4. Internal heat generation (appliances and people)
5. Design conditions (typical outdoor and indoor weather conditions)

A scientific calculation called a Heat Loss/Heat Gain tabulates these factors into a worst case heating and cooling design for the climate zone where the home is located. By comparing the heat loss/gain to manufacturer's equipment performance data, a properly sized heating and cooling system is selected.

To more fully understand the Heat Loss/Heat Gain calculation it can be helpful to take a more in depth look at the five factors discussed above.

Insulating value Scientific research has determined the resistance to heat transfer (insulating/ r-values) for the components and groups of components that go into the construction of a home. The heat loss/heat gain calculates the amount of heat transfer by component based on the surface area and then tabulates the total transfer for all of the components.

Air leakage/air infiltration

Approximately 50% of an average home's heat loss/heat gain is attributable to air leakage. Therefore, determining the proper leakage rate for a specific home is paramount. Design leakage rates are based on dwelling size and projected efficiency or actual measured performance.

Solar orientation

The amount of window surface area and the direction a home faces can have tremendous impact on the cooling needs (heat gain). Similar houses with different solar orientation will have different cooling loads. Glass facing east/west has more heat gain than glass facing north/south

Internal Heat Generation
Standard allowances are made for typical internal heat load like kitchen equipment and people. Abnormal loads like home offices or indoor hot tubs must be addressed separately.

Design Conditions
Design conditions are the typical average worst case winter and summer outdoor temperatures and the normal indoor thermostat settings for these respective seasons. The outdoor design condition is derived from 30-year weather averages, as gathered by the National Weather Service for the area in which the home is being constructed.

There are two acceptable outdoor design conditions. The first uses an outdoor design temperature that is exceeded by the 30-year minimum or maximum average temperature 2.5% of the time. The second outdoor design condition is exceed by the maximum or minimum average temperature 0% of the time. Both design conditions include air moisture (humidity) averages for the determination of summer dehumidification needs. For example Richmond, Virginia's, outdoor design temperatures are:

2.5%	Heating	17
	Cooling	92
0%	Heating	10
	Cooling	95

Even at the 0% design criterion, there will be occasions when the temperature exceeds design conditions. In some years, there may be numerous or extended periods when outdoor temperatures exceed design conditions; however, over a 30 year average these extremes do not warrant design consideration.

The industry standard for residential indoor design conditions is 70 degrees Fahrenheit heating and 75 degrees Fahrenheit cooling /50-55% relative humidity. This recommendation is made by the Air Conditioning Contractors of America (ACCA) and the American Society of Heating, Refrigerating and Air - Conditioning Engineers, Inc. (ASHRAE). Planned indoor settings outside of the industry standard must be discussed with the installing contractor and addressed in the heat loss/gain calculation.

The result of the heat loss/heat gain calculation is a winter and summer worst-case design condition represented in BTUH (British Thermal Units per Hour). Unlike the winter design, the summer design is a product of two components, the sensible load (temperature) and the latent load (humidity). The air conditioning unit chosen for the job must meet both of these loads to provide proper cooling and dehumidification. Since heat pumps do both heating and cooling, they are sized for the cooling load and a supplemental heat source is used to meet any additional heating needs.

Bigger Is Not Better

The choice of a heating and cooling system that closely matches the homes load conditions is paramount to ensuring proper performance and comfort. A properly sized system should operate for longer periods as the outdoor temperature approaches the design temperature. At the design temperature, the system should run at or near 100% of the time while maintaining the designed indoor temperature. On rare occasions when outdoor design temperatures are exceeded, indoor design temperatures may not be maintained. This condition should only be temporary and does not warrant increased sizing because of the potential for short cycling, premature failure and higher than intended operating costs.

Short cycling is the phenomenon of meeting the thermostats setting too quickly to properly filter, mix or dehumidify indoor air. The typical air conditioning system must run 8-10 minutes before the dehumidification process begins. When the system is oversized, the dehumidification process is almost eliminated until outdoor temperatures are high enough to create long run times. Premature equipment failure, increased repair costs and high operating costs can also be expected due to the increased stress and decreased efficiency of a starting and stopping motor, much like a car used for city driving versus highway driving.