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Overview of "HVAC Systems" in General Aspects

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Abstract: The Management and Automation of a Commercial building Heating, Ventilation and Air Conditioning (H.V.A.C) System has got enormous benefits from the use of all the available information sources. The modern H.V.A.C using direct digital control methods have provided useful performance data from the building occupants. The untapped data can be cultivated with the help of modern maintenance management databases. This research work has got the integration and application of these fundamental sources of information, using some modern and novel techniques. The cost and scalability of these techniques can be positively influenced by the recent technological advancement in computing power, sensors and databases. The important theme of this research paper is to increase the computational efficiency and practical usefulness of techniques, via some clever approximations.
Keywords: HVAC, Roof Top Units, Package Units, Mechanical Design Contractors, Economizers, HVAC Controls, Integrated Design, Energy Savings.

I. INTRODUCTION

Heat Ventilating and Air Conditioning (HVAC) relates to systems that perform processes designed to regulate the air conditions within buildings for the comfort and safety of occupants or for commercial and industrial processes or for storage of goods. HVAC systems condition and move air to desired areas of an indoor environment to create and maintain desirable temperature, humidity, ventilation and air purity.

Depending on geographic location and building construction, various types of interior climate control systems help ensure that interior spaces are maintained at comfortable levels year-round. With today's energy conservation concerns, buildings are constructed to be much tighter, reducing the level of natural exchange between indoor and outdoor air. As a result, more and more buildings rely on mechanical conditioning and distribution systems for managing air.

A properly operated HVAC system must be properly designed sized and installed and finds the often-delicate balance between optimizing occupant comfort while controlling operating costs. Comfort is an important issue for occupant satisfaction, which can directly affect concentration and productivity. At the same time, controlling these comfort and health parameters directly affects HVAC system operating costs in terms of energy, maintenance and equipment life.

II. SIZING

When considering a HVAC system for a residence, remember that energy efficient and passive solar homes have less demand for heating and cooling. Substantial savings may be obtained by installing smaller units that are properly sized to meet the load. Because energy bills in more efficient homes are lower, higher efficiency systems will not provide as much annual savings on energy bills and may not be as cost effective as in less efficient homes.

Not only does oversized equipment cost more, but also it can waste energy. Oversized equipment may also decrease comfort. For example, an oversized air conditioner cools a house but may not provide adequate dehumidification. This cool but clammy air creates an uncomfortable environment.

Many contractors select air conditioning systems based on a rule, such as 600 square feet of cooled area per ton of air conditioning (a ton provides 12,000 Btu per hour of cooling). Instead, use a sizing procedure such as:

A. Calculations in Manual J published by the Air Conditioning Contractors Association;
B. Similar procedures developed by the American Society of Heating, Refrigeration, and Air
C. Conditioning Engineers (ASHRAE); or
D. Software procedures developed by electric or gas utilities, the U.S. Department of Energy or
E. HVAC equipment manufacturers.

The heating and cooling load calculations rely on the outside *winter and summer design temperatures* (see the appendix for a definition) and the size and type of construction for each component of the building envelope, as well as the heat given off by the

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lights, people, and equipment inside the house. If a zoned heating and cooling system is used, the loads in each zone should be calculated. Table 2-1compares the size of heating and cooling systems. The more efficient home reduces the heating load35% and the cooling load 26%. Thus, less cost from reducing the size of theHVAC equipment offset the additional cost of the energy features in the more efficient home.

Table2-1 Equipment Sizing Comparison

HVAC System Sizing			
Type of House	Code Home HERS=98	®ENERGY STAR Home HERS=85	Exceeds ENERGY STAR® Home HERS=70
Heating(BTU/hour)	52,200	38,800	25,700
Cooling (BTU/hour)	31,700	25,700	19,800
Estimated tons of cooling*	3.0	2.5	2.0
Square feet/ton	667	800	1,000

*Estimated at 110% of calculated size. There are 12,000 Btu/hour in a ton of cooling.

Oversimplified rules-of-thumb would have provided an oversized heating and cooling system for the more efficient home. The typical rule-of-thumb in Kentucky has been to allow for600 square feet per ton of air conditioning. Since the home has 2,000square feet of conditioned space, HVAC contractors could well provide 3.5 to 4 tons of cooling (2,000 ÷ 600 = 3.33, then roundup.) The oversized unit would have cost more to install. In addition, the operating costs would be higher. The oversized unit would suffer greater wear and may not provide adequate dehumidification.

Proper sizing includes designing the cooling system to provide adequate dehumidification. In a mixed- humid climate, it is important to calculate the latent load. The latent load is the amount of dehumidification needed for the home. If the latent load is ignored, the home may become uncomfortable due to excess humidity.

The Sensible Heating Fraction (SHF)designates the portion of the cooling load for reducing indoor temperatures (sensible cooling).For example, in a HVAC unit with a 0.75 SHF,75% of the energy expended by the unit goes to cool the temperature of indoor air. The remaining 25% goes for latent heat removal—taking moisture out of the air in the home. To accurately estimate the cooling load, the designer of a HVAC system must also calculate the desired SHF and thus, the latent load.

Many homes in Climate Zone 4 have design SHFs of approximately 0.7. This means that 70% of the cooling will be sensible and30%latent.Systemsthatdeliverlessthan30%latentcoolingmay fail to provide adequate dehumidification in summer. It takes 15 minutes for most air conditioners to reach peak efficiency. During extreme outside temperatures (under32°Fin winter and over 88°Fin summer), the system should run about 80% of the time. Oversized systems cool the home quickly and often never reach their peak operating efficiency.

III. TEMPERATURE CONTROL

The most basic type of control system is a heating and cooling thermostat. Programmable thermostats, also called setback thermostats, can be big energy savers for homes. These programmable thermostats automatically adjust the temperature setting when people are sleeping or are not at home. Be certain that the programmable thermostat selected is designed for the particular heating and cooling equipment it will be controlling. This is especially important for heat pumps, as an improper programmable thermostat can actually increase energy bills.

A thermostat should be located centrally within the house or zone. It should not receive direct sunlight or be near a heat-producing appliance. A good location is often 4 to 5 feet above the fluorine interior hallway near return grille. The interior wall, on which it is installed, should be well sealed at the top and bottom to prevent circulation of cool air in winter or hot air in summer. Some homeowners have experienced discomfort and increased energy bills for years because air from the attic leaked into the wall cavity behind the thermostat and caused the cooling or heating system to run much longer than needed.

IV. ZONED HVAC SYSTEM

Larger homes often use two or more separate heating and air conditioning units for different floors or areas. Multiple systems can

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maintain greater comfort throughout the house while saving energy by allowing different zones of the house to be at different temperatures. The greatest savings come when a unit serving an unoccupied zone can be turned off. Rather than install two separate systems, HVAC contractors can provide automatic zoning systems that operate with one system. The ductwork in these systems typically has a series of thermostatically controlled dampers that regulate the flow of air to each zone. Although somewhat new in residential construction, thermostats, dampers, and controls for zoning large central systems have been used for years in commercial buildings.

If you're heating and air conditioning subcontractors feel that installing two or three separate HVAC units is necessary, have them also estimate the cost of a single system with damper control over the ductwork. Such a system must be carefully designed to ensure that the blower is not damaged if dampers are closed to several supply ducts. In this situation, the blower still tries to deliver the same airflows before, but now through only a few ducts. Back pressure created against the blades of the blower may cause damage to the motor. There are three primary design options:

1. Install a manufactured system that uses a damper bypass duct connecting the supply plenum to the return duct work .Installing the bypass damper is the typical approach .When only one zone is open, the bypass damper, which responds automatically to changes in pressure in the duct system, will open to allow some of the supply air to take a shortcut directly back to the return, thus decreasing the overall pressure in the ductwork (Figure 4-1).
2. Create two zones and oversize the ductwork so that when the damper to one zone is closed, the blower will not suffer damage. This approach is only recommended for two zones of approximately equal heating and cooling loads.
3. Use a variable speed HVAC system with a variable speed fan for the duct system. Because variable speed systems are usually more efficient than single-speed systems, they will further increase savings.

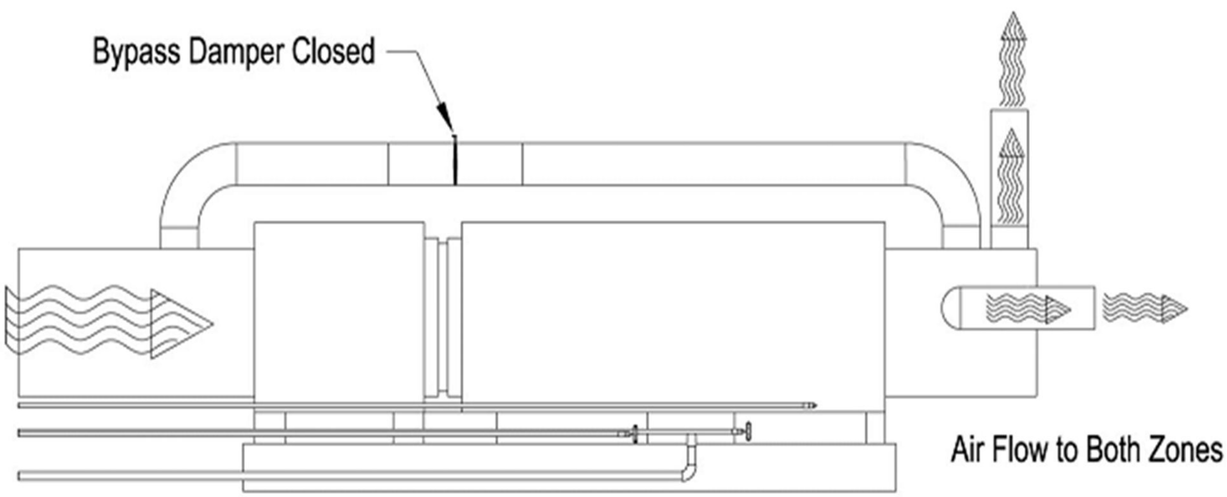

Figure 4-1Automatic zone system

A. Cooling Equipment Selection

Table's 1-2and 1-3 show equipment charts for two sample air conditioning units. Each system provides a wide range of outputs, depending on the blower speed and the temperature conditions. The SHF(Sensible Heating Fraction) is the fraction of the total output that cools down the air temperature. The remainder of the output dehumidifies the air and is the latent cooling. Note that both systems provide about 36,000Btu/hour of cooling.

1) Consider System A(Table 4-1) with 80°Freturn air and SEER 15:
2) At low fan speed, System A provides 35,800 Btu/hour, 0.71 SHF, and thus 29% latent cooling (dehumidification).
3) At high fan speed, System A provides 38,800Btu/hour, but a 0.81 SHF, and only 19% latent cooling. This is not enough dehumidification in many Kentucky homes.

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Table4-1 Sample Cooling System A Data, SEER 15

Total Air Volume (cfm)	Total Cooling Capacity (Btu/h)	Sensible Heating Fraction (SHF) Dry Bulb(°F)		
		75°F	80°F	85°F
950	35,800	0.58	0.71	0.84
1,200	37,500	0.61	0.76	0.91
1,450	38,800	0.64	0.81	0.96

A. Consider System B(Table4-2) with 80°Freturn air and SEER 13:
B. At low fan speed, System B provides 32,000 Btu/ hour, 0.67 SHF and 33% dehumidification.
C. At high fan speed, System B provides 35,600 Btu/hour, 0.76 SHF and 24% dehumidification.

Table4-2 Sample Cooling System B Data, SEER 13

Total Air Volume (cfm)	Total Cooling Capacity (Btu/h)	Sensible Heating Fraction (SHF) Dry Bulb(°F)		
		75°F	80°F	85°F
950	32,000	0.56	0.67	0.78
1,200	34,100	0.58	0.71	0.84
1,450	35,600	0.61	0.76	0.90

Thus System A, while nominally more efficient than B, provides less dehumidification and potentially less comfort.

A. ventilationandindoorairquality

All houses need ventilation to remove stale interior air and excessive moisture and to provide oxygen for the inhabitants. There has been considerable concern recently about how much ventilation is required to maintain the quality of air in homes. While it is difficult to gauge the severity of indoor air quality problems, building science experts and most indoor air quality specialists agree that the solution is not to build an inefficient, “leaky” home.

Research studies show that standard houses are as likely to have indoor air quality problems as energy efficient ones. While opening and closing windows offers one way to control outside air for ventilation, this strategy is rarely useful on a regular, year-round basis. Most building researchers believe that no house is so leaky that the occupants can be relieved of concerns about indoor air quality. The researchers recommend mechanical ventilation systems for all houses.

The amount of ventilation required depends on the number of occupants and their lifestyle, as well as the design of the home. The ANSI/ASHRAE standard, “Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings”(ANSI/ASHRAE 62.2-2007) recommends that houses have 7.5 natural cubic feet per minute of fresh air per bedroom + 1, plus additional airflow equal to (in cubic feet per minute) 1% of the house conditioned area, measured in square feet. In addition, the standard requires exhaust fans in the kitchen and bathrooms that can be operated when needed.

For example, consider a 2,000 square foot home, with3 bedrooms, and assume occupancy of 4 people. The amount of ventilation recommended by ASHRAE would be 50 cfm: 7.5 cfm x (3+ 1) + 1% x 2,000 = 30 cfm + 20 cfm = 50 cfm

Increasing the number of occupants or increasing the square footage of the home would increase the necessary ventilation requirements. Older, drafty houses can have natural air leakageof1.0 to 2.5 ACHnat. Standard homebuilt today are tighter and usually have rates of from 0.35 to 0.75 ACHnat. New energy efficient homes have rates of 0.30 AC Hnator less. The problems are that air leaks are not a reliable source of fresh air and are not controllable.

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The ENERGY STAR®rating system includes a consideration of homes that are tightly constructed. If the home has a measured natural air leakage rate below 0.35ACHnat, the HERS score will not improve unless mechanical ventilation is provided. If the measured natural air leakage rate is below 0.25, the software will provide a warning that additional ventilation air should be provided and the amount needed.

Air leaks are unpredictable, and leakage rates for all houses vary. For example, air leakage is greater during cold, windy periods and can be quite low during hot weather. Thus, pollutants may accumulate during periods of calm weather even in drafty houses. These homes will also have many days when excessive infiltration provides too much ventilation, causing discomfort, high energy bills, and possible deterioration of the building envelope.

Concerns about indoor air quality are leading more and more homeowners to install controlled ventilation systems for providing a reliable source of fresh air. The simplest approach is to provide spot ventilation of bathrooms and kitchens to control moisture (see Figure 4.2). Nearly all exhaust fans in standard construction are ineffective—a prime contributor to interior moisture problems in homes. Bath and kitchen exhaust fans should vent to the outside, not just into an attic or crawl space. General guidelines call for providing a minimum of 50 cubic feet per minute (cfm) of airflow for baths and100 cfm for kitchens. Manufacturers should supply a cubic feet per minute (cfm) rating for any exhaust fan.

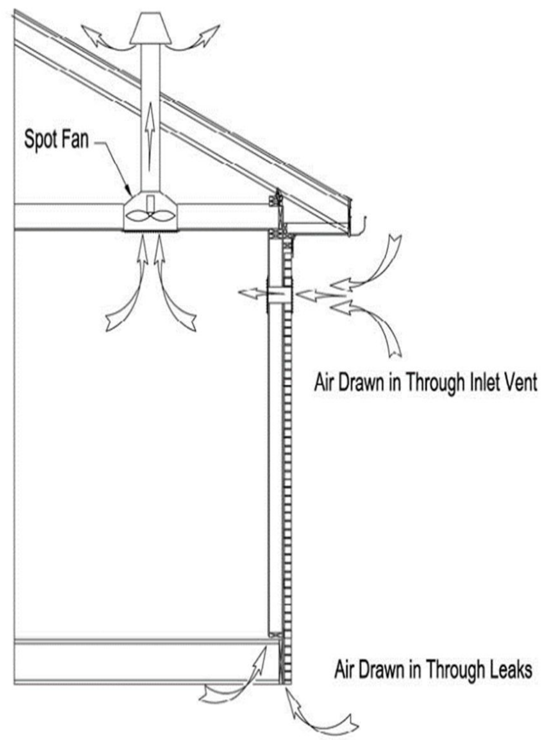

Figure 4-2 Ventilation with Spot Fan

The cubic feet per minute rating typically assumes the fan is working against an air pressure resistance of 0.1 inch of water column—the resistance provided by about 15 feet of straight, smooth metal duct. In practice, most fans are vented with flexible duct that provides much more resistance. Most fans are also rated at pressures of 0.25 to 0.30 inches of water column—the resistance found in most installations.

While ENERGY STAR®fans cost more; they are cheaper to operate and are usually better constructed and therefore, last longer and run quieter. The level of noise for a fan is measured in sones. Choose a fan with sones rating of 2.0 or lower.

Top quality models are often below 0.5 sones.

Many ceiling- or wall-mounted exhaust fans can be adapted as "in-line" blower's located outside of the living area, such as in an attic or basement. Manufacturers also offer in-line fans to vent a single bath or kitchen, or multiple rooms. Distancing the in-line fan, Figure 4-3, from the living area lessens noise problems.

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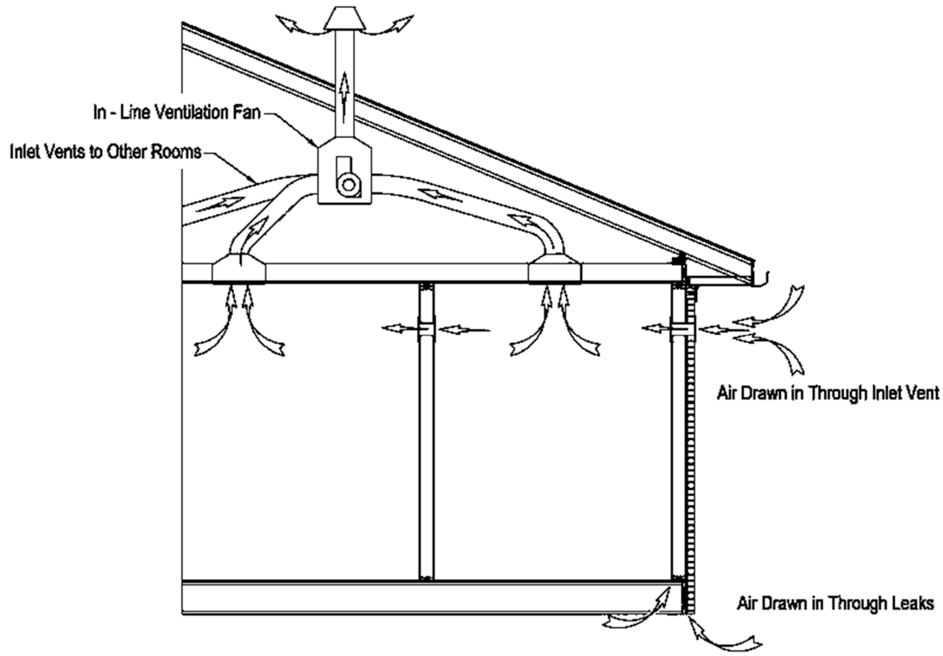

Figure 4-3 In–Line Ventilation with Spot Fan

While improving spot ventilation will certainly help control moisture problems, it may not provide adequate ventilation for the entire home. A whole house ventilation system can exhaust air from the kitchen, all baths, the main living area, and bedrooms.

Whole house ventilation systems usually have large single fans located in the attic or basement. Ductwork extends to rooms requiring ventilation. These units typically have two-speed motors. The low speed setting gives continuous ventilation—usually 10 cubic feet per minute per person or 0.35 ACH. The high speed setting can quickly vent moisture or odors.

B. Supplying Outside Air From Air Leaks

The air vented from the home by exhaust fans must be replaced by outside air. This new air comes into the home either through air leakage or through a controlled inlet. Relying on air leaks requires no extra equipment; however, the occupant has little control over the air entry points. Many of the air leaks come from undesirable locations, such as crawl spaces or attics. If the home is airtight, the ventilation fans will not be able to pull in enough outside air to balance the air being exhausted. This generates a negative pressure in the home, which may cause increased were on fan motors. In addition, the exhaust fans may threaten air quality by pulling exhaust gases from flues and chimneys back into the home.

C. Supplying Outside Air From Inlet Vents

Providing fresh outside air through inlet vents is another option. These vents can often be purchased from energy specialty outlets by mail order. They are usually located in exterior walls. The amount of air they allow into the home can be controlled manually or by humidity sensors. Locate inlet vents where they will not create uncomfortable drafts. These inlet vents are often installed in bedroom closets with louvered doors or high on exterior walls.

D. Supplying Outside Air Via Ducted Make-Up Air

Outside air can also be drawn into and distributed through the home via the ducts for a forced-air heating and cooling system. This type of system usually has an automatically controlled outside air damper in the return duct system.

The blower for the ventilation system is either the air handler for the heating and cooling system or a smaller unit that is strictly designed to provide ventilation air. Alight disadvantage of using the HVAC blower is that incoming ventilation air may have sufficient velocity to affect comfort during cold weather.

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The return ductwork for the heating and cooling system may be connected to a small outside air duct that has a damper which opens when the ventilation fan operates. The incoming air flow should not adversely affect comfort. Special controls are available to ensure that the air handler runs a certain percentage of every hour, thus providing fresh air on a regular basis.

E. Dehumidification-Ventilation System

Kentucky homes are often more humid than desired. A combined dehumidification-ventilation system can bring in fresh (but humid outdoor air), remove moisture, and supply it to the home (see Figure 4-4). These systems can also filter incoming air. These systems require an additional mechanical device. A dehumidifier must be installed on the air supply duct. This dehumidifier should be designed for the specific needs of the home.

A well-designed conventional A/C system without outdoor ventilation air should not need supplemental dehumidification. It is the excess moisture in outdoor ventilation air that may require the special dehumidification equipment, especially when mild outdoor temperatures do not require the cooling system to operate many hours per day to maintain the set point temperature.

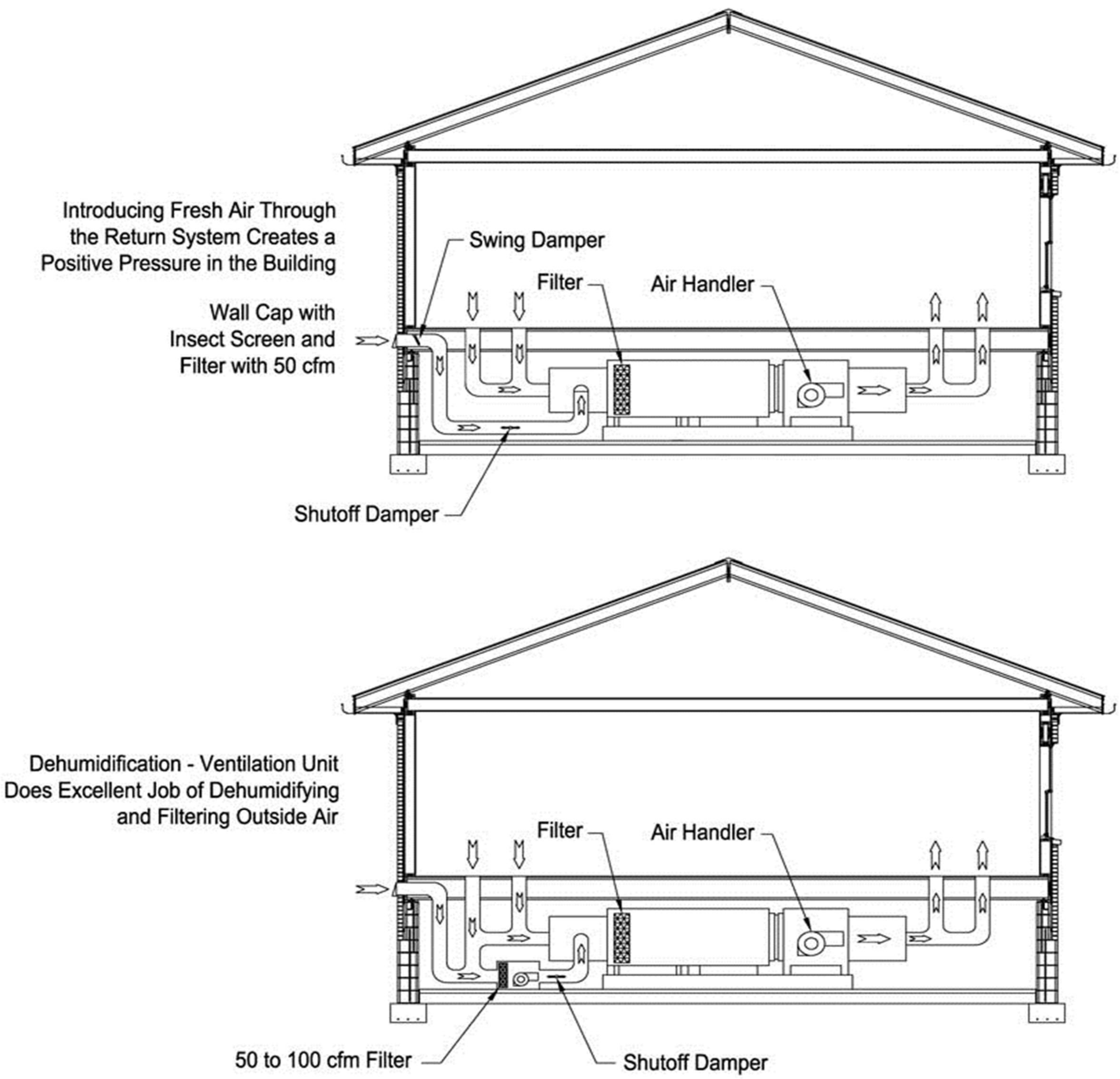

Figure 4-4 Fresh Air and Dehumidification Strategies

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F. Heat Recovery Ventilation

Air-to-air heat exchangers or heat recovery ventilators (HRV), typically have separate duct systems that draw in outside air for ventilation and distribute fresh air throughout the house. Winter heat from stale room air is “exchanged” for the cooler incoming air. Some models, called enthalpy heat exchangers, can also recapture cooling energy in summer by exchanging moisture between exhaust and supply air. The value of any heat recovery ventilation system should not be determined solely on the cost of recovered energy. The controlled ventilation and improved quality of the indoor environment must be considered as well.

G. Sample Ventilaion Plans

Three options for providing a mechanical ventilation system for a home are shown in the following designs. While providing mechanical ventilation plans is routine for commercial buildings, their use in homes is just beginning. As a result, few standard designs exist and sometime will be needed for them to be developed for different climates.

V. DESINING

A. DESIGN 1: Upgraded Spot Exhaust Ventilation

This relatively simple and inexpensive whole house ventilation system, Figure 1-5, integrates spot ventilation using bathroom and kitchen exhaust fans with an upgraded exhaust fan (usually 100 to 150 cfm) in a centrally located bathroom. When the fan operates, outside air is drawn through inlets in closets with louvered doors. A timer, set to provide ventilation at regular intervals, controls the fan. Interior doors are undercut to allow air flow to the central exhaust fan. The fan must be a long-life, high-quality unit that operates quietly. In addition to the automatic ventilation provided by this system, occupantscan turn on all exhaust fans manually as needed.

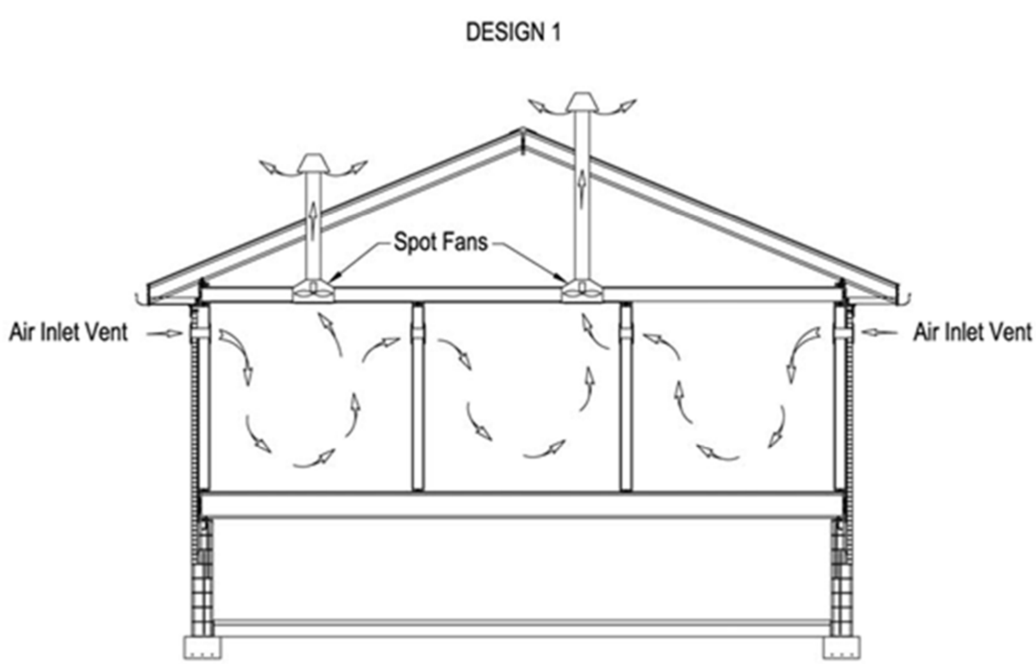

Figure 5-1 Upgraded Spot Exhaust Ventilation

B. DESIGN 2: Whole Huse Ventilation System

This whole house ventilation system uses a centralized two-speed exhaust fan to draw air from the kitchen, bath, laundry, and living areas. A timer controls the blower. The system should provide approximately 0.35 natural air changes per hour(ACHnat) on low speed and1.0 ACHnat on high speed. A separate dampered duct connected to the return air system supplies outside air. When the exhaust fan operates, Figure 1-6, the outside air damper opens and allows air to be drawn into the house throughthe forced-air ductwork.

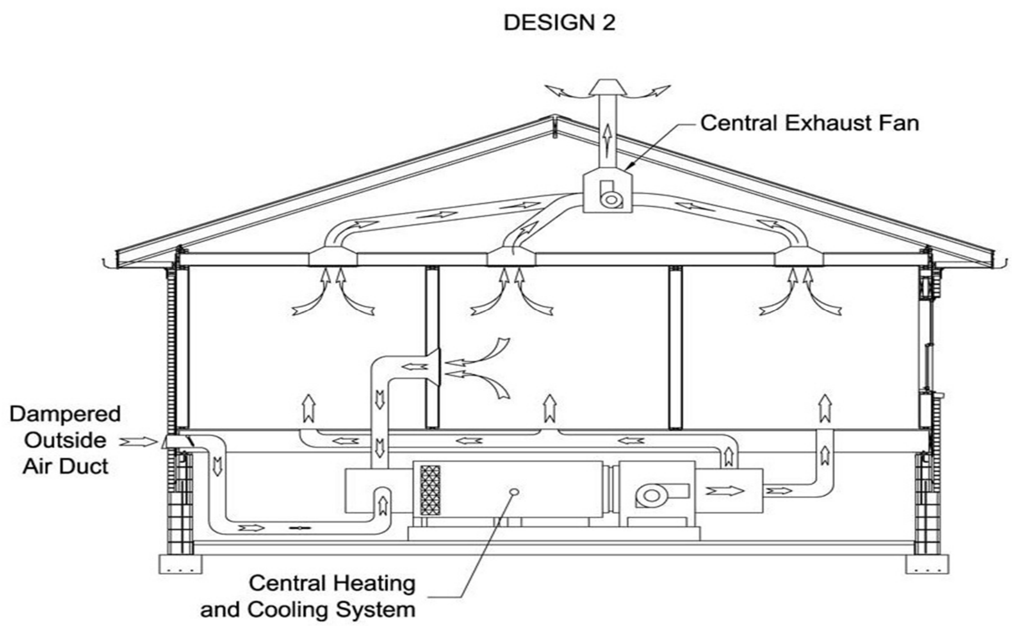

Figure 5-2Whole House Ventilation System

C. DESIGN 3: Heat Recovery Ventilation (HRV) System

An enthalpy recovery ventilator draws fresh outside air through a duct into the heat exchange equipment and recaptures heating or cooling energy from stale room air as it is being exhausted (see Figure 1-7). The system also dries incoming humid air in summer. This is a particular benefit in the Southeast. Fresh air flows into the house via a separate duct system, which should be sealed as tightly as the HVAC ductwork. Room air can either be ducted to the exchanger from several rooms or to a single source. Some HRV units can be wall-mounted in the living area, while others are designed for utility room's orbasements.

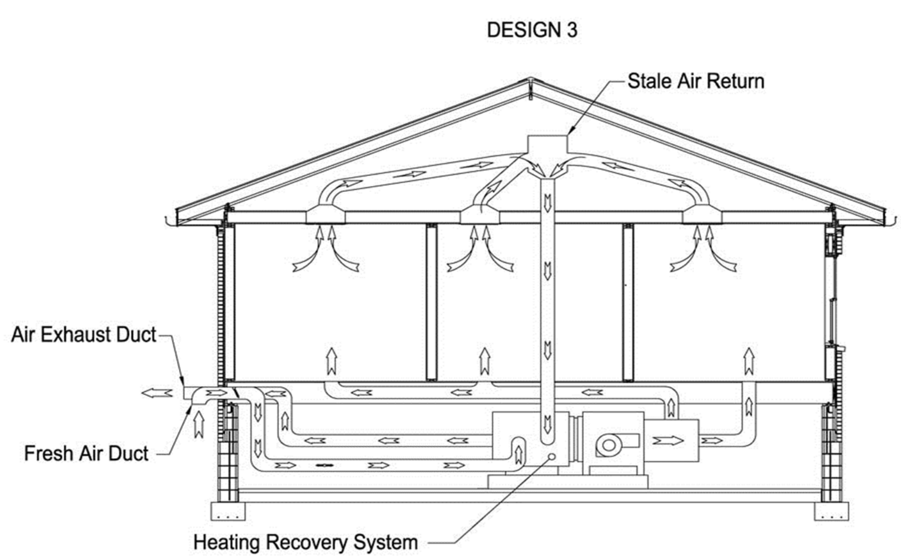

Figure 5-3 Heat Recovery Ventilation (HRV) System

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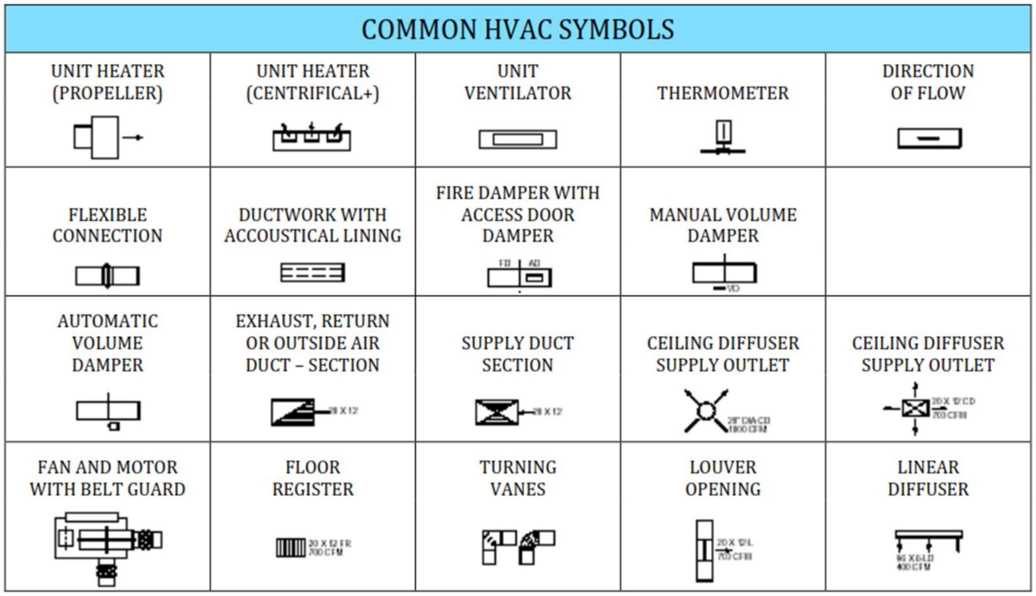

VI. CONCLUSION

Proper system design accounts for building type and size, layout, surrounding area, the nature of activities taking place, the number of occupants, climate and other factors, making each situation distinct. A good understanding of the entire HVAC system from the outdoor air intake to the furthest diffuser is essential for good management.

In optimizing system operation, a number of economic factors must be considered, including fuel source and cost, electricity consumption, filtration, life of the equipment, maintenance costs and more. These must be balanced against occupant comfort and special manufacturing or storage considerations.

Making and analyzing certain key measurements is essential for optimizing the HVAC system performance. Information collected gives you the tools to make the correct decisions.

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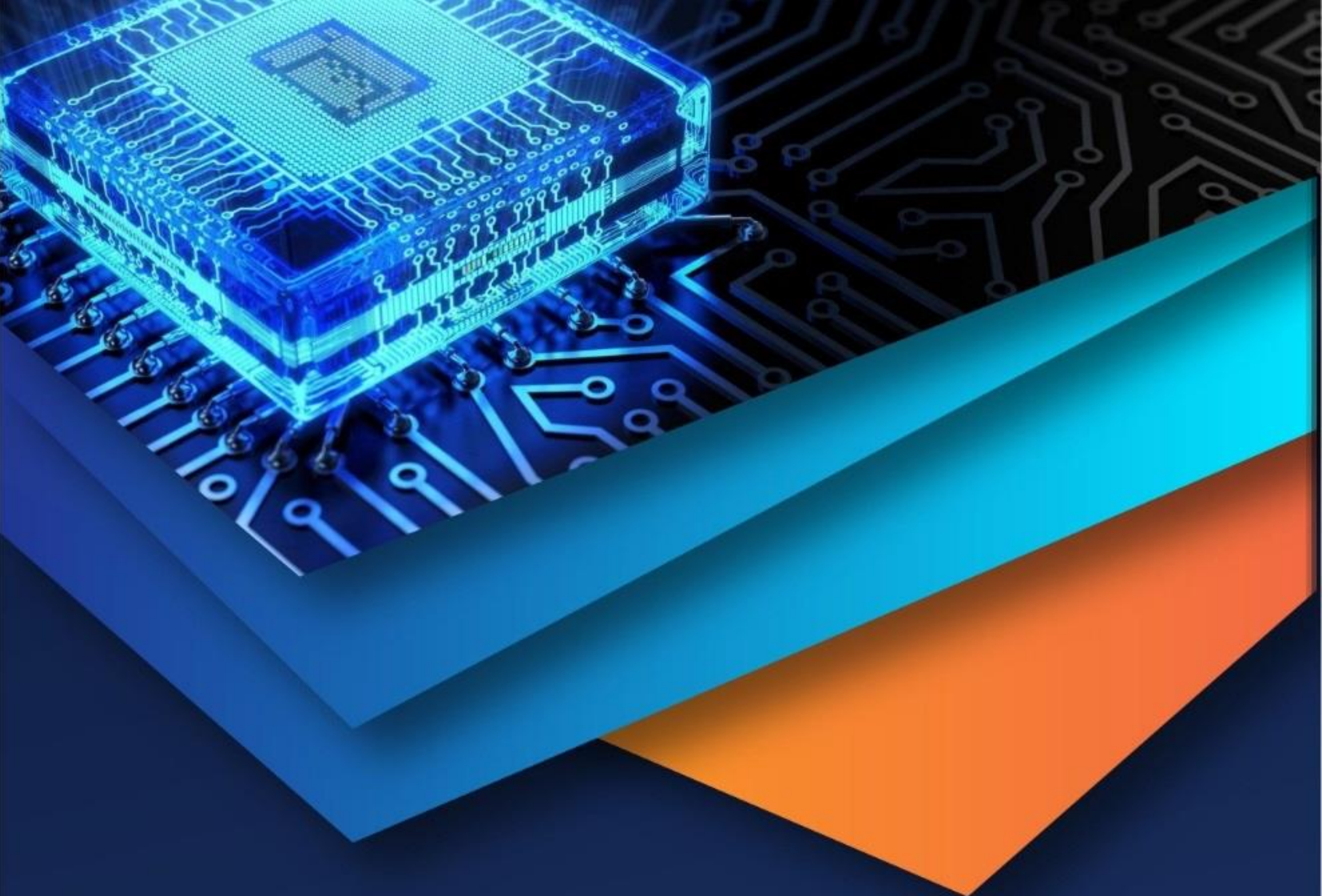

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