BUSINESS PROGRAMS

Heating Ventilating and Air Conditioning Systems: Facts Every Building Designer/Owner Should Know

TECHNICAL DATA SHEET

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Occupants of commercial buildings often believe—mistakenly—that most of a building's energy is consumed by equipment they can see. Lights, electronic equipment and computers represent obvious energy users. However, the equipment that consumes 39 percent of the energy in a commercial building in the United States cannot be seen at all—the HVAC equipment. HVAC systems are critically important, however, because they maintain occupant comfort, productivity and health.

Because three distinct processes and a fourth system are involved, energy efficiency modifications to one HVAC process can significantly affect—either enhance or reduce—the potential energy savings available from another process or the entire system.

Heating, ventilating and air conditioning (HVAC) represent three distinct processes that work in a highly integrated system. A fourth system, controls, affects each of the three processes as well as the HVAC system as a whole. When an HVAC system is well designed and maintained, it can operate very efficiently, reduce emissions and cut energy costs for building owners.

However, HVAC systems are not always designed, operated or maintained properly, so they are excellent candidates for energy efficiency improvements. HVAC systems do present challenges to facility managers and engineers as they attempt to enhance system efficiencies. Because three distinct processes and a fourth system are involved, energy efficiency modifications to one process can significantly affect—either enhance or reduce—the potential energy savings available from another process or the entire system. Therefore, the potential energy saving benefits are substantial, but to achieve them often requires a skilled HVAC contractor or engineer.

HVAC AND CONTROLS: BRIEF DEFINITIONS

The heating process warms building occupants by either heating the air or directly heating the occupants. Air systems include supply air systems. Direct heating uses radiant systems on building surfaces. First, boilers generate steam or hot water. These generally operate using natural gas or fuel oil. Firetube steel, watertube steel and cast iron boilers range from 78 percent to 86 percent efficient. Condensing boilers are typically fired with natural gas and are 95 percent to 96 percent efficient. Second, furnaces use natural gas, fuel oil and electricity. Finally, heat pumps use electricity to add heat to or extract it from a conditioned space, much like a refrigerator works.

The ventilating process moves air throughout a building. Ventilation air can be 100 percent outside air or a mixture of outside air with indoor recirculated air. Ventilation impacts occupant comfort and productivity. However, it also affects health and safety. Effective ventilating ensures that indoor air maintains the proper mix of oxygen and carbon dioxide and expels or dissipates harmful gases such as carbon monoxide. Ventilation can occur naturally, such as through doors and windows, or mechanically, using electric-powered air handling systems. There are two types of ventilating systems: constant air volume (CAV) and variable air volume (VAV).

Air conditioning cools air by reducing its temperature (sensible cooling) and removing moisture from it (latent cooling). Humid climates often require dehumidification for maximum comfort and dry climates need some humidification. Air conditioners generally transfer heat or send it outdoors via air or water cooled equipment and the majority operate using electricity. Air conditioning equipment can include rooftop units, chillers, condensers and/or cooling towers.

Finally, controls manage each of these processes independently and as a system. They ensure that equipment operates safely and efficiently and maintains occupant comfort. Heating controls are generally found on boilers; they increase energy efficiency by reducing on/off cycling. Ventilating controls manage and control airflow throughout a building. Typical systems include direct digital control (DDC) systems and CO_2-based control systems. CAV and VAV systems have their own control mechanisms.

Air conditioning systems use variable speed drives, variable speed or multi-speed fans and integrated chiller plant controls.

NEW HVAC SYSTEMS: AIM FOR HIGH PERFORMANCE DESIGNS

When constructing a new building, designers and owners should take a High Performance Design approach. That is, they should ensure that the building's design considers how all elements interact. These elements include siting, thermal envelope and lighting. All three affect HVAC process and control choices.

- HVAC load is based on the building's placement on its acreage and its geographic configuration. Does one side of the building face directly south? If so, it will require more summer cooling than a different design.
- A building envelope's thermal performance determines HVAC equipment choices and sizing. The term "building envelope" refers to its "skin" and includes factors such as exterior façade material, insulation, the presence or absence of thermal coverings and windows and doors. If the elements of a building's envelope are selected with energy efficiency in mind, then the HVAC system can be smaller.
- Light fixtures and lamps emit heat, and this excess heat must be considered when cooling and ventilating a building. When daylighting is incorporated into a building's lighting plan, there will be fewer electric lights to emit this waste heat.

Each of these three elements will determine an HVAC system's requirements for piping, ducting, fans and pumps. When an HVAC system is sized properly, a building's owner will incur lower equipment costs up front as well as potentially lower operating costs over the equipment's lifetime.

A High Performance HVAC design approach considers five steps:

1. Size the HVAC system correctly ("right size"). Oversized equipment costs more to operate and maintain and it will not run as efficiently as a properly sized system. Do not specify larger HVAC equipment than needed in anticipation of a future building expansion. Instead, incorporate space to add HVAC capacity, if needed.
2. When selecting equipment, evaluate how it performs when operating at part load, not fully loaded. HVAC equipment is designed to operate at peak-rated efficiency only when it is operating fully loaded. However, most HVAC equipment operates fully loaded only 1 percent to 2.5 percent of the time. In fact, most systems operate at 50 percent or less of their capacity.
3. Design distribution systems (ductwork or piping) that reduce pressure losses. This choice results in smaller pumps and fans and lower operating costs.
4. Use integrated control systems to operate the HVAC system. These control systems will help meet fluctuating HVAC loads efficiently by coordinating system operations. A DDC system also offers more information feedback for control decisions and more precise control.
5. Commission the HVAC system. This step tests the system under all aspects of operation before the building opens for business. It identifies problems and ensures the system is operating as intended.

MAXIMIZING HVAC ENERGY EFFICIENCY: KEY STEPS

Building owners/operators can take several steps to ensure an existing HVAC system is operating as energy efficiently as possible.

- Maintain the system regularly and have it tuned by HVAC contractors or engineers to maximize operations.
- Ensure the control systems are operating properly and use them.
- Control equipment so that: 1) it operates at minimum required capacity using resets and setpoints and variable speed technology for fans and motors; 2) peak demand is minimized through demand limiting or load shedding; 3) equipment is started up sequentially.

For additional information, contact Focus on Energy at 800.762.7077, visit www.focusonenergy.com, or refer to the sources listed below.

Sources: Whole Building Design Guide, "High Performance HVAC", "Office Building," www.wbdg.org. "Environmental Concerns," www.sustainabledesignguide.umn.edu.

Energy Design Resources Design Brief, "Air Conditioning and Ventilation," "Chiller Plant Efficiency," "Energy Management Systems," "Options and Opportunities," "Economizers," "Underfloor Air Distribution and Access Floors," www.energydesignresources.com.