

■ The Application

CAV, or Constant Air Volume systems are central ventilation systems usually used to supply large common zones with the minimum amounts of fresh tempered air. They preceded VAV systems and therefore are found in older multi-zoned commercial buildings as well. These systems preheat the fresh

air utilizing Air Handling Units (AHUs) with a heating coil, and many are also used to air condition buildings and have a cooling coil. Fan coil units are frequently used to assist in the heating and cooling requirements in the individual zones.

■ The Design

CAV systems bring outside air into Air Handling Units (AHU) where the air is frequently pre-heated. Central fans typically blow the air across heating and sometimes cooling coils into ductwork which brings the fresh air to the large common zones in the building. This air is then expected to circulate throughout the building naturally and each individual zone has fan coils or other temperature control devices to properly temper the zone. An extract or return fan is also located in the AHU as a part of the CAV system.

This fan returns the air from the individual zones back to the air handling unit where it is re-circulated or exhausted outside.

CAV systems are designed to flood an area with pre-conditioned air, regardless of the needs of the zone. As with most HVAC systems, the systems are designed for “worst case” and end up wasting energy relative to the needs of the building for most of their operational life. No modulation method normally exists other than the original balancing of the system. The only conventional energy savings methods are on/off control and two speed motors.

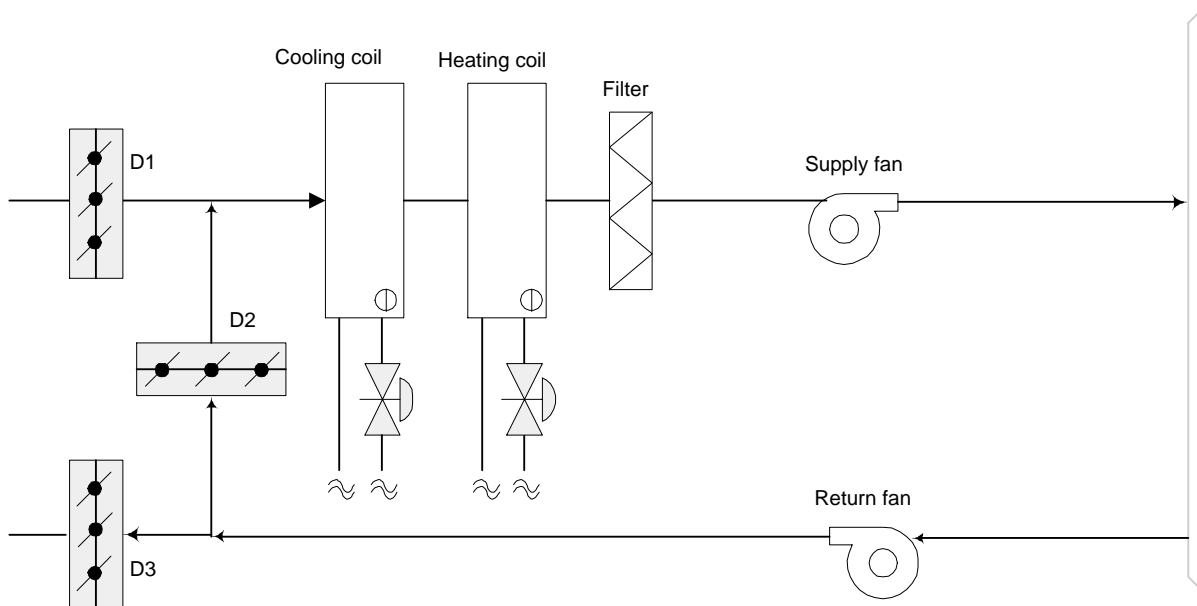


Fig. 1
Traditional CAV Ventilation system

■ **The new standard:**

With a VLT frequency converter, significant energy savings can be obtained while maintaining decent control of the building. Temperature sensors or CO2 sensors can be used as feedback signals to VLT frequency converters. Whether controlling temperature, air quality, or both, a CAV system can be controlled to operate based on actual building conditions. As the number of people in the controlled area decreases, the need for fresh air decreases. The CO2 sensor detects lower levels and decreases the supply fans speed. The return fan modulates to maintain a static pressure setpoint or fixed difference between the supply and return air flows. With temperature control, especially used in air conditioning systems, as the outside temperature varies as well as the number of people in the controlled zone changes, different cooling requirements exist. In an air conditioning system as the temperature decreases below the setpoint, the supply fan can decrease its speed. By decreasing the air flow, energy used to heat or cool the fresh air is also reduced, adding further savings. The return fan modulates to maintain a static pressure setpoint.

Several features of Danfoss HVAC dedicated VLT frequency converter, the VLT 6000 HVAC can be utilized to improve the performance of your CAV system. One concern of controlling a ventilation system is poor air quality. The programmable minimum frequency can be set to maintain a minimum amount of supply air regardless of the feedback or reference signal. The VLT frequency converter also includes a two zone, 2 setpoint PID controller which allows monitoring both temperature and air quality. Even if the temperature requirement is satisfied, the drive will maintain enough supply air to satisfy the air quality sensor. The controller is capable of monitoring and comparing two feedback signals to control the return fan by maintaining a fixed differential air flow between the supply and return ducts as well.

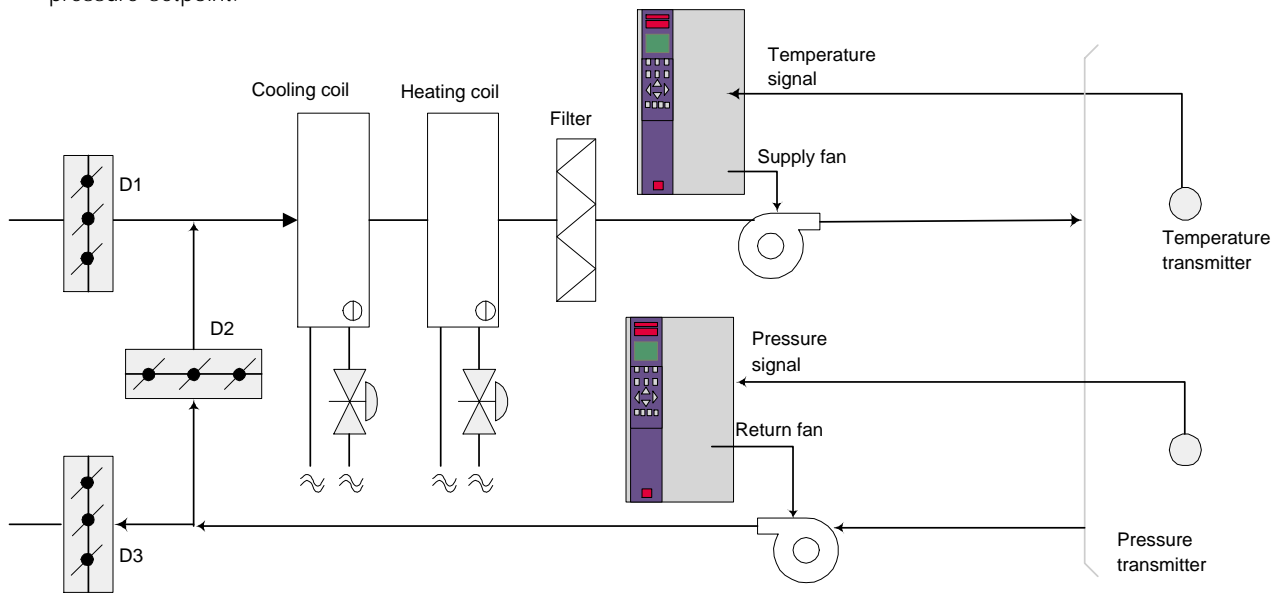


Fig. 2
CAV system with VLT frequency converters

■ **Specific energy consumption**

Fig. 3 shows the specific energy consumption of several regulation methods at variable flow. Graph 1 shows the theoretical energy consumption according to the basic *Fan Laws*, graph 2 the *VLT solution*, graph 3 and 4 *Two speed motor* and graph 5 *full speed*.

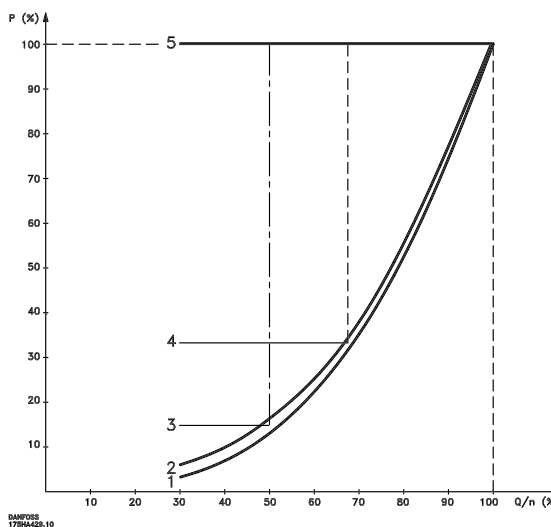
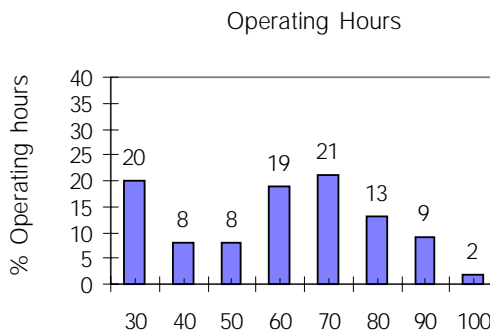


Figure 3: Variable Speed Pump Curves

■ **Annual operation load profile**

To calculate your potential savings, one must look at the actual load profile. The load profile indicates the amount of flow the system requires to satisfy its loads during the typical day or time period under study. Figure 4 shows a typical load profile for CAV systems. This profile will vary depending on the specific needs of each system due to location and other factors, but is representative of normal systems.



% Max. volume flow rate
Fig. 4

■ **Energy saving calculation example**

In the following calculation example a 30 kW fan is operated according to the load profile shown in fig. 4. The energy consumption during one year running time is calculated for an AHU comparing the unregulated system with the VLT frequency converter solution. The comparison shows an energy savings of over 68%.

Flow (%)	Hours (%)	Hours run	Power Consumption (kW)		Energy input for 30 kW Pump motor	
			CAV	VLT 6000 HVAC	CAV	VLT 6000 HVAC
30	20	1752	28	1	49056	1752
40	8	701	28	2	19622	1402
50	8	701	28	4	19622	2803
60	19	1664	28	7	46603	11651
70	21	1840	28	11	51509	20236
80	13	1139	28	15	31886	17082
90	9	788	28	22	22075	17345
100	2	175	28	29	4906	5081
	100%	8760 Hours			245280 kWh	77351 kWh

■ Sensor Type And Placement

When air quality or temperature control is used, the sensor placement and VLT frequency converter adjustment is important to help avoid possible problems with stratification and dumping. A minimum speed can be set to insure a minimum fresh air intake if required or a minimum pressure at the CAV diffusers. Sensors should be placed at body level in the zone away from the diffuser or in the return duct. Two or more sensors can also be used to average the zones conditions to avoid improper control. While not the ideal system for energy savings or temperature control, retrofitting a CAV system with a VLT frequency converter is very economical and can result in significant energy savings.

The return fan is frequently controlled to maintain a fixed difference in airflow between the supply and return. Again, the internal PID controller can be utilized to eliminate the need for an additional external controller.

■ Comparison of installation and maintenance costs

Aside from the large potential energy savings, the utilization of a properly designed VLT frequency converter partially pays for itself with installation and maintenance savings. VLT frequency converters eliminate the need for several electrical components. Soft starter, 6 motor cables, and power factor correction capacitors are all no longer needed. Not only does this reduce the first cost of VLT frequency converters, but also simplifies installation and maintenance. The mechanical costs are also reduced by eliminating the need for the throttling valve on the discharge of the pumps. The soft-starting inherent to our variable speed VLT frequency converters eliminates high starting currents and reduces the stress on the motor and bearings.

Utilizing the Danfoss VLT frequency converters, a simple voltage or current control signal is sufficient. Our dedicated HVAC converter will allow stand alone operation. It is also simple to control our VLT frequency converter using serial communications. With our standard RS485 connection and open protocol, Johnson Controls' Metasys N2 and Landis & Staefa's FLN protocols built in, and Lonworks and other high performance field bus option cards, we are sure to support your buildings needs.



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