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From : Clerk to Panel

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LegCo Panel on Environmental Affairs

Follow-up to meeting on 29 March 1999

At the Panel meeting on 29 March 1999 when the Innovative Energy Efficient Equipment Pilot Programme for Government Buildings was discussed, members have requested the Administration to provide further information on the direct savings of Phase II of the Pilot Programme and the recommodations to be made to the public funded bodies on energy saving. The requisite information has been provided by the Administration and is attached for members' reference.

(Mrs Mary TANG)
for Clerk to Panel

Encl.

c.c. All other Hon Members of LegCo
ASG1
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For information

LEGISLATIVE COUNCIL
PANEL ON ENVIRONMENTAL AFFAIRS

Innovative Energy Efficient Equipment Pilot Programme for Government Buildings

BACKGROUND

1. At the Panel meeting on 29 March 1999, the Administration briefed members on Phase I of the Pilot Programme and a proposal to commence the Phase II. Members asked for further information on the direct savings of the Phase II of the Pilot Programme and the recommendations to be made to public funded bodies on energy saving.

SAVINGS FROM PHASE 2 PROGRAMME

2. Building on the experiences gained in Phase I of the Programme and using a payback period of five years, we expected that direct savings for Phase II of the Programme would be about $1.2 million. A breakdown of the savings for the different types of equipment is at Annex A. However, there will be much greater savings if such equipment is installed as part of the original building services design, rather than retrofitting. We also expect equipment prices to fall as volumes increase in response to demand and market competition.

Annex A

RECOMMENDATIONS TO PUBLIC FUNDED BODIES

3. We are preparing guidelines to provide recommendations to building professionals on retrofitting energy efficient equipment. Draft guidelines for use of electronic ballast and variable speed drives are at Annex B. We will publish the guidelines in July 1999 and distribute it to public-funded organisations as well as the private organisations including property developers and facility managers. The guidelines will also be available in the EMSD internet home page for public access. The guidelines will be published in English language only.

Annex B

4. We intend to provide a simplified, less technical pamphlet to highlight the potential energy and cost savings for the benefit of non-building professionals such as office managers, members of owner’s committees, etc. The pamphlet will be prepared in both Chinese and English languages.

Planning, Environment and Lands Bureau
June 1999

Annex A

Estimated Direct Savings from Energy Equipment Used in Phase II

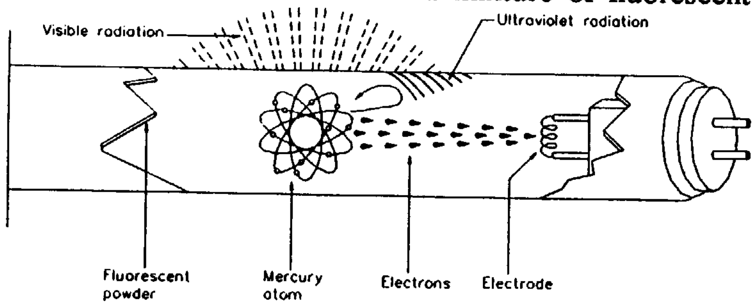
Proposed Innovative Energy Efficient Equipment	Estimated Cost ($ Million)	Estimate Direct Savings ($ Million)
(a) Lighting and Power		
Dimmable Lighting Ballast	0.6	0.12
Combined Electronic Ballast & Emergency Modules	0.2	0.04
T5 Fluorescent Lamps	0.5	0.1
Intelligent Lighting Control System	0.2	0.04
(b) Air-conditioning		
Presence Detection for Air-conditioning Control	1.1	0.2
Indirect Evaporative Heat Recovery System	1.9	0.4
(c) Lifts and escalators		
Energy Optimiser in Motor & Drive System	1.5	0.3

Total: **6.0** **1.2**

Annex I
附件 B

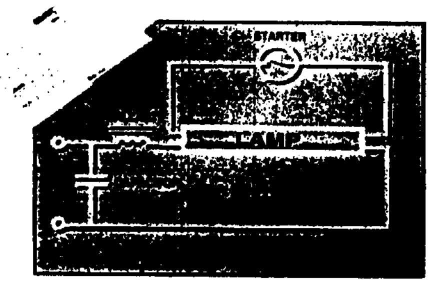
APPLICATION GUIDE TO ELECTRONIC BALLASTS

Fluorescent lamp is by far the most widespread of all discharge lamp type. It is employed almost universally especially in office lighting. The most common type of fluorescent lamp is tubular linear in shape ranged from 600mm (18W) to 1500mm (58W) in length. The discharged tube has an electrode sealed into each end and is filled with an inert gas and a small amount of mercury, the latter being present in both liquid and vapour form. The inside of the tube is coated with a mixture of fluorescent powders.

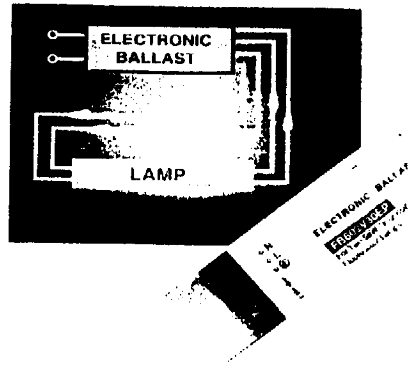


These convert the ultraviolet radiation of the mercury discharge into longer wavelengths within the visible range. A great many different fluorescent powders or 'phosphors' are available for any desired colour temperature and colour rendering characteristics.

Unlike an incandescent lamp, a fluorescent lamp cannot be connected directly to the mains. Some device to limit the electric current flowing through it must be included in the circuit. This device can be **electromagnetic (conventional) ballast** with starter or **electronic ballast** operating at high frequency.



Conventional Ballasts



The basic construction of typical electronic ballast involves a low-pass filter, rectifier, buffer capacitor and a high frequency oscillator. The basic operation principle is that after passing a low-pass filter, the mains voltage at 50Hz power frequency is rectified in an AC/DC converter. This converter also contains the buffer capacitor, which is charged with a DC voltage. In the HF power generator this DC voltage is transformed into a HF voltage, which provides the power to the lamp.

The ballast takes advantage of a characteristic of fluorescent lamp whereby greater efficacy is obtained at high operating frequency above 10kHz. Efficacy due to high frequency operation is increased by about 10% thereby enabling the lamp to be operated at a lower input power than at 50Hz mains power frequency. Ballast losses are reduced compared to conventional ballast, as the solid state circuit contains no copper windings. In the case of a twin 1200mm 36W lamp circuit the losses can be reduced from 24W to a mere 6W when using an electronic ballast. The overall achievement in a suitable luminaire, therefore, is an **energy reduction** in the region of **20% to 30%**. These energy saving features enable lighting levels to be maintained with a dramatic cut in electricity costs. With less heat generated, the cooling load on air conditioning equipment will also be reduced.

The **overall lighting system efficacy** can be increased by **20 to 30 percents** due to three main factors:

1. Improved lamp efficacy at high frequency operation.
2. Reduced circuit power losses.
3. Lamp operates closer to optimum performance in most enclosed luminaires.

Other **benefits** electronic ballast offered include:

- Rapid or instant starting of lamp without flickering.
- Single ballast can be designed to drive one, two, three or even four lamps.
- Increased lamp life due to lower lamp operating current.
- Quiet operation without audible noise.
- No visible flicker during operation.
- No stroboscopic effect and HF operation.
- Lower total harmonic distortion (THD)
- High total power factor due to low THD and cosθ.
- Cooler ambient temperature inside luminaires for optimum operation of lamp, control gear, capacitor and batteries for emergency lighting.
- No carbonisation and blackening to luminaire and decoration in the vicinity.
- Less effect on variation of luminous flux due to mains supply voltage fluctuations.
- Much lighter in weight.

Common Lamp Wattage of Fluorescent Lamps

Nominal Lamp Length	T12	T8	T8 (HF)	T5
600mm	20W	18W	17W	14W
1200mm	40W	36W	32W	28W
1500mm	65W	58W	-	35W

Suitability of Ballast Types for various Fluorescent Lamp Groups

Lamp Group	Conventional Ballast	Low Loss Ballast	Electronic Ballast	Dimmable Ballast (Magnetic)	Dimmable Ballast (Electronic)
T12 (38mm)	✓	✓	✗	✓	✗
T8 kryton-filled (25mm)	✓	✓	✓	✗	✓
T8 argon-filled HF (25mm)	✗	✗	✓	✗	✓
T5 (16mm)	✗	✗	✓	✗	✓

Product Range available for Electronic Ballasts

Product Range of Electronic Ballasts Available for T8 Lamps										
1x18W	2x18W	3x18W	4x18W	1x32W	2x32W	1x36W	2x36W	3x36W	1x58W	2x58W

To ensure **quality** of electronic ballasts, the following national or international standards must be specified:

- IEC 928/EN 60928/GB 15143-94A.C.-supplied electronic ballasts for tubular fluorescent lamps - General & safety requirements
- IEC 929/EN 60929/GB 15144-94A.C.-supplied electronic ballasts for tubular fluorescent lamps - Performance requirements
- IEC 1000-3-2/EN 61000-3-2 Limits for harmonic current emission (equipment input current ≤ 16A per phase)
- EN 55015 Limit and method of measurement of radio disturbance characteristics of lighting and similar equipment
- FCC, 47 CFR Part 18: non-consumer equipment: conducted interference and radiated interference ≥ 30Mhz

The **electromagnetic compatibility (EMC)** is basically determined by the characteristics of electronic ballast in combination with the luminaire design. The following technical aspects and basic rules have to be considered by designers in applying electronic ballasts in luminaires:

1) Effective protective earth must be provided for all exposed conductive parts of the metal luminaire.
2) Functional earth is required to fulfil certain EMC requirements or to guarantee proper operation of the system.
3) Ensure a firm electrical connection between the electronic ballast and the metal luminaire.
4) Mains power wiring and lamp wiring inside luminaire must be as short as possible, firmly mounted on spacers and far away from each other to minimise stray capacitance.
5) Provide good electrical contact between metal luminaire and reflector and/or louvres. Reflector and louvres serve as a shielding around the lamp.

Check List for Electronic Replacement in Existing Luminaires:

- T8 fluorescent lamp uses 10% less energy than its T12 or T10 counterparts. If the existing lamps are T12 or T10, it is more beneficial to change them to T8 prior to retrofit with electronic ballast.
- Electronic ballast is designed for specific lamp type and lamp wattage, make sure that the appropriate type of electronic ballast is selected for replacement.
- It is more cost effective to use electronic ballasts to operate multi-lamps in luminaires with more than one lamp.
- For location where frequent switching is required, warm or rapid start electronic ballasts have to be specified.
- For location where frequent switching is not required, cold or instant start electronic ballasts could be used. Cold start electronic ballasts do not require preheating for starting and are more energy efficient.
- To avoid high inrush current and incidental MCB tripping, a lighting switch should not operate more than 10 luminaires with electronic ballasts.
- All existing conventional ballast, starter and power factor correction capacitor must be removed from the retrofit luminaire.

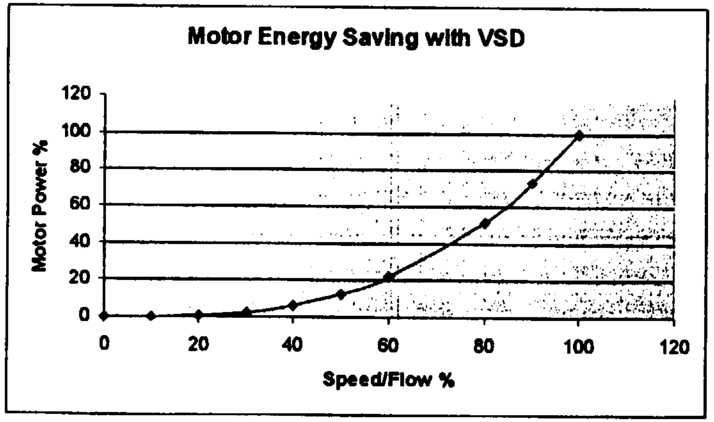
For more information about the application of electronic ballasts, please contact the Energy Efficiency Office at tel no. 2881 1562

Electrical & Mechanical Services Department

APPLICATION GUIDE TO VARIABLE SPEED DRIVES (VSD)

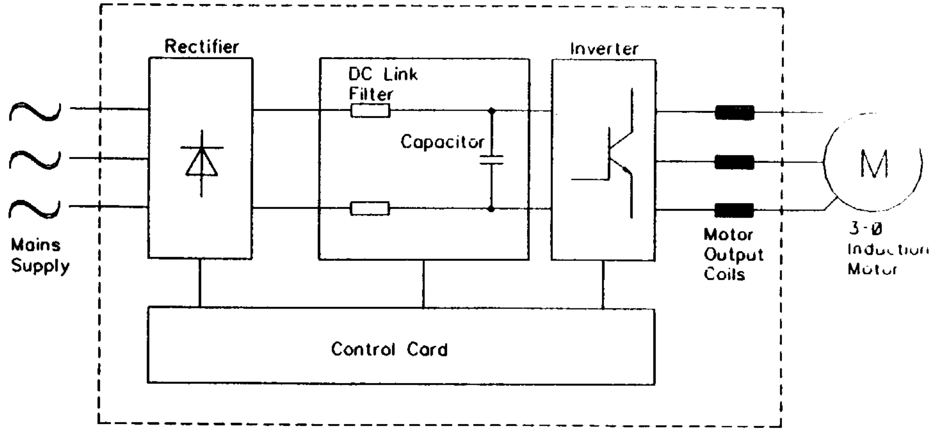
In Hong Kong, most of the 3-phase ac motors in buildings are fitted to fans and pumps. The flow from most fans and pumps is either constant or controlled by restricting the flow by mechanical means, e.g. dampers are used on fans and valves are used on pumps. This mechanical constriction will control the flow and may reduce the load on the fan or pump motor, but the constriction itself adds an energy loss that is obviously inefficient. Hence if the flow can be controlled by reducing the speed of the fan or pump motor, more efficient means of achieving flow control could be offered

As the speed of the fan or pump is reduced, the flow will reduce proportionally, while the power required by the fan or the pump will reduce with the cube of the speed. This level of potential energy saving makes the use of Variable Speed Drive (VSD) a cost-effective investments in energy efficiency which can be considered for motors.



In recent years, development in power semiconductors and microprocessors have allowed the introduction of electronic VSDs which have improved performance and reliability over earlier systems while reducing the equipment cost. Hence a range of motors in building services can now be considered for retrofitting with VSD based on the economics of energy saving.

A VSD can be regarded as a frequency converter rectifying ac voltages from the mains supply into dc, and then modifies this into a ac voltage with variable amplitude and frequency. The motor is thus supplied with variable voltage and frequency, which enables infinitely variable speed regulation of three-phase, asynchronous standard induction motors.



Application of VSD in Primary Air-Handling Units (PAU)

Conventional fresh air supply introduced into a high-rise commercial building is normally fed via a Primary Air-handling Unit (PAU) at constant air volume. The conventional PAU is part of a central air conditioning system usually used to supply fresh conditioned air via riser ductwork to the floors it served at constant rate, regardless of the actual needs of the zones served. The PAU brings outside air, at a designed temperature of 33.5°C, into filters prior to pre-cooling it to 20°C and delivers it via fans and ductwork to serve individual floors. This system is designed for "worst case" condition and end up wasting energy relative to the needs of the building for most of the operational life. No modulation method had normally been allowed in the design other than the original balancing of the system. The system is normally operated continuously from 8:00 am to 6:00 pm for general offices building.

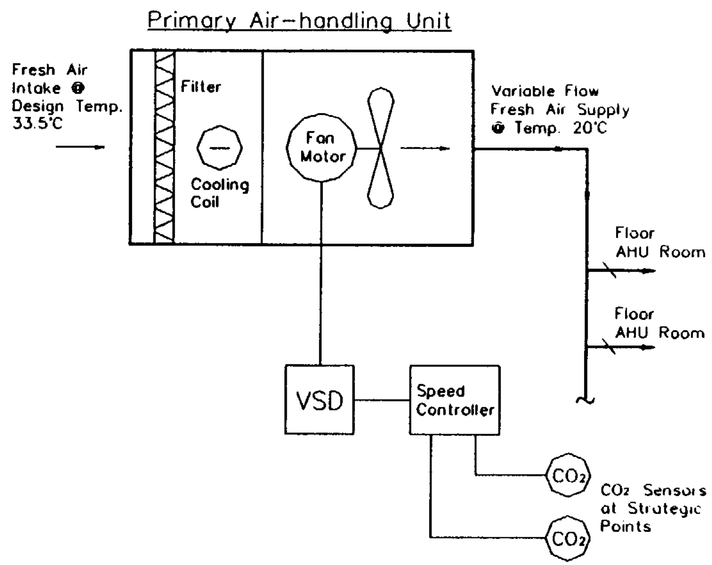
Demand control on PAUs using carbon dioxide offers a unique opportunity for building services engineers and building owners to resolve the problem of how to reduce energy costs while optimising indoor air quality.

CO_2 control is best applied to spaces with variable or intermittent occupancy. These applications can include lecture halls/classrooms, conference/meeting rooms, theatres, waiting areas, and even office spaces. In space without variable occupancy, CO_2 control can ensure that the space is ventilated at the appropriate level for its occupancy, rather than being ventilated at an arbitrary rate determined sometime when the building was designed.

In a typical building, the amount of CO_2 exhaled by people is diluted by outside air introduced by mechanical ventilation, air leakage, and open windows. The lowest concentration of CO_2 measured in outside air in Hong Kong ranging from 400 to 500 ppm. The CO_2 concentration measured in Causeway Bay was found to be on the high side of 500 ppm. CO_2 is generally not considered a health-threatening contaminant at the 500 to 3,000 ppm levels typically found in most buildings. Many people have observed symptoms of stuffiness, sleepy, inattention, unpleasant odours, and a general feeling of discomfort as CO_2 levels rise about 1,400 ppm. It is important to note that these symptoms are not directly related to CO_2 or a corresponding lack of oxygen. Rather these reactions are more related to the build-up of other contaminants and irritants in the space when ventilation levels are low. CO_2 is therefore often considered a good surrogate indicator of indoor air quality.

According to ASHRAE Standard 62-1989 " Ventilation for Acceptable Indoor Air Quality", ventilation maintaining an indoor CO_2 content of 1000 ppm is considered ideal. CO_2 lower than 800 ppm is considered as over-ventilated. Some of the government office buildings investigated under the Pilot EMO Implementation Programme have average measured CO_2 concentration below 700 ppm. Therefore CO_2 based demand control ventilation has good potential to reduce energy consumption while optimising indoor air quality.

The CO_2 based demand control can also be achieved by the direct application of CO_2 sensors for real time speed control of PAU. Recent innovations in gas sensor designs have considerably improved the long-term performance and cost of CO_2 sensors, making it one of the fast growing segments of the HVAC control industry. The CO_2 sensors should be located at some strategic location where "worst case" occurred. The figure below shows a possible arrangement of a variable flow PAU using VSD and CO_2 sensors.

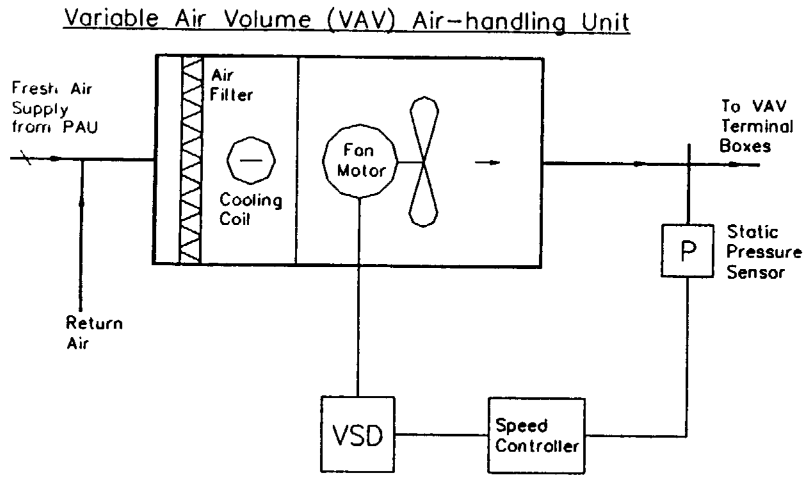


Application of VSD in Variable Air Volume (VAV) Air-Handling Units

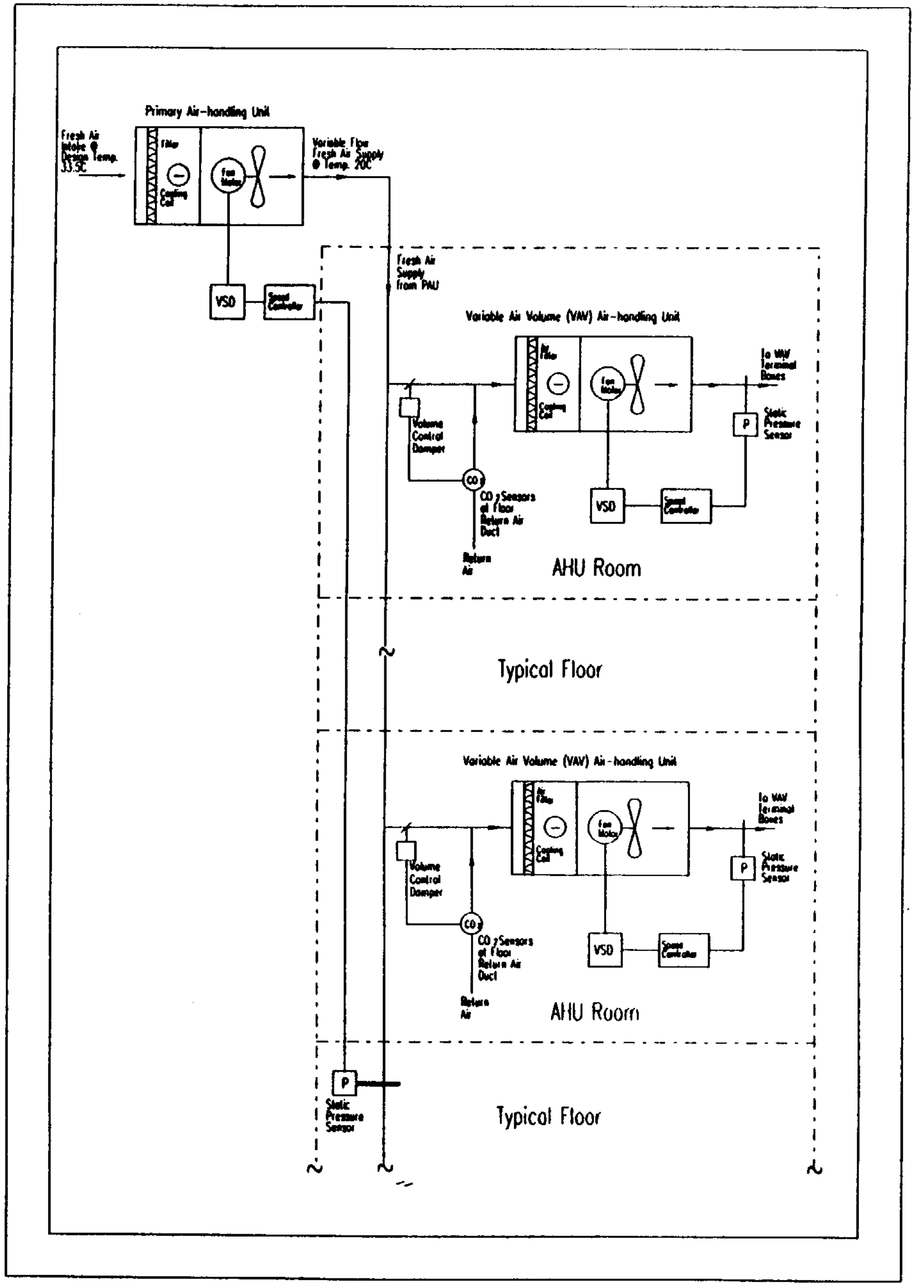
Variable Air Volume (VAV) systems typically bring conditioned air from PAU and returned air from the air-conditioned space into Air Handling Units (AHU) where the air temperature and humidity can be adjusted. Fans blow air across filter, cooling coils and volume control dampers or inlet guide vanes into ductwork, which distributes the air throughout the zones served. The air passes into each zone from the ductwork through individual VAV terminal boxes. A temperature sensor located in each zone is connected to its VAV box and opens or closes the VAV box to maintain the defined temperature setpoint. As the zone becomes satisfied, the VAV box modulates to a close position. The pressure in the ductwork would then begin to rise as the openings in the VAV box close.

Traditionally, inlet guide vanes or discharged dampers are installed in the AHUs to prevent this over pressurisation and save energy. These devices work by creating resistance and a pressure drop to the air entering the ductwork or reducing the efficiency of the fan. The more the VAV boxes in the system close, the more the dampers close to maintain static duct pressure. The dampers or inlet guide vanes for the fan are commonly controlled by a controller maintaining a fixed pressure in the supply ductwork downstream of the AHU.

While dampers and inlet guide vanes work to maintain a constant pressure in the ductwork of a VAV system, the utilisation of VSD could save much more energy and reduce the complexity of the installation. Instead of creating an artificial pressure drop or causing a decrease in fan efficiency, the VSD decrease the speed of the fan to provide the flow and pressure required by the system. The figure below shows a modified VAV system with VSD in lieu of the conventional star-delta motor starter and motorised dampers for static pressure control in the ductwork.



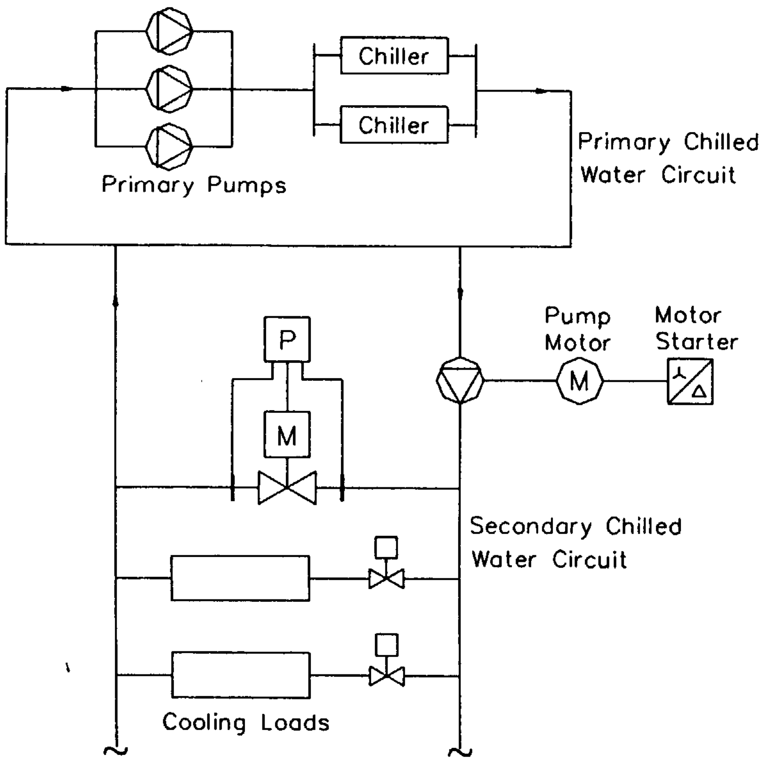
For **new high-rise building projects** involving CO_2-based demand control ventilation via central PAUs, it would be more appropriate to include individual duct-mounted CO_2 sensors at the return air ducts to control the amount of fresh air drawn from the main riser duct at the AHU rooms on each floor. The total demand of fresh air required to be handled by PAUs should then be control either via static pressure sensors in the main air duct or summation of individual fresh air requirement at each floor together with appropriate DDC controllers and VSDs. A typical configuration diagram of the system is shown in the figure below



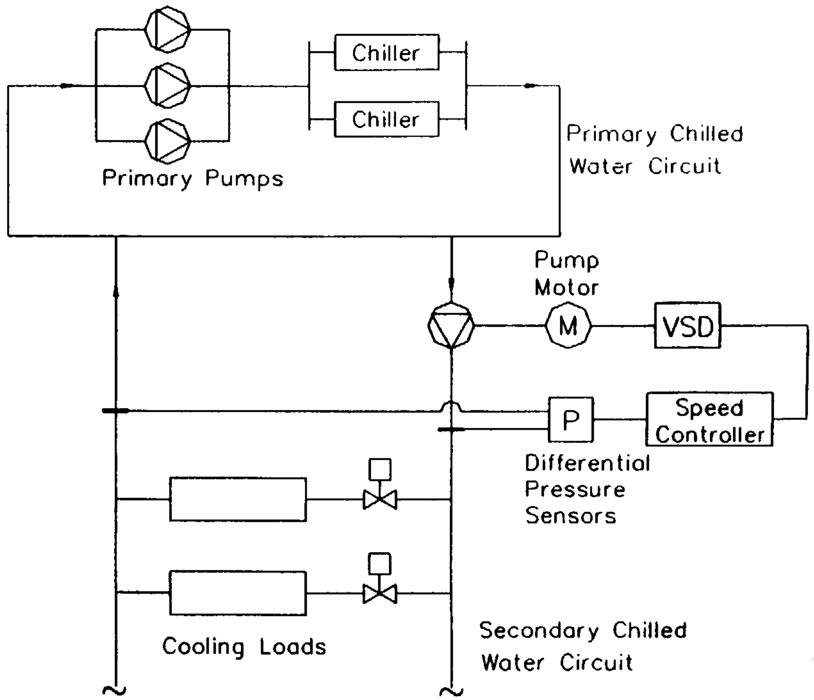
Application of VSD in Secondary Chilled Water Circuit

Primary pumps in a primary/secondary pumping can be used to maintain a constant flow through chillers that encounter operation or control difficulties when exposed to variable flow.

In chilled water systems, the primary loop consists of primary pumps sized to handle the chillers designed flow rate at a discharge pressure just high enough to circulate the water through the chiller and the rest of the primary piping loop. The secondary chilled water loop is a variable flow system consists of secondary pumps sized to circulate chilled water to handle full capacity of the cooling loads connected on the circuit. During light load condition, most of the two-port control valves on the loads are not fully open resulting in pressure rise in the secondary chilled water loop. In a conventional system, a by-pass valve connected across the cooling loads will be used to by-pass the secondary water flow and regulate the flow to loads and balance the water pressure in the system. A differential pressure sensor normally controls the by-pass valve.



The figure shows a new arrangement of the secondary chilled water circuit with VSD in lieu of by-pass valve for regulation chilled water flow according to the actual loading requirement. Energy saving is achieved in pump motors in most of the time when the cooling loads are not at full capacity and maximum chilled water flow is not required.



For more information about the application of VSDs in building air conditioning systems, please contact the Energy Efficiency Office at tel no. 2881 1562

Electrical & Mechanical Services Department