空調系統空氣側節能技術

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二、空氣側節能技術

三、室內空氣分佈--節能與舒適度

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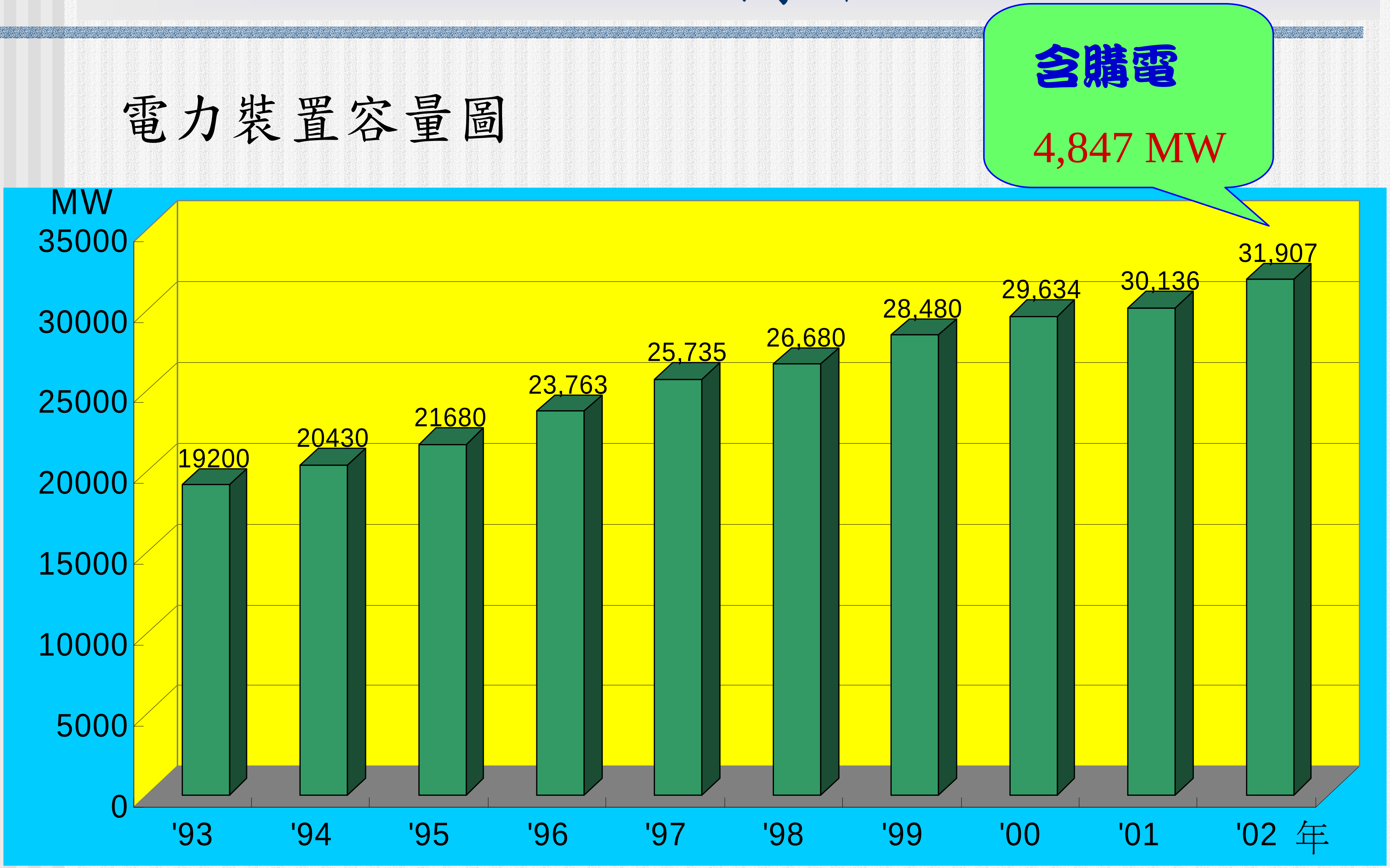
一、簡介

- 隨著產品精緻化及成本量產考量，製程程序與機台量隨之增加，不僅是需要空調來排除機台熱負載，對廠內空氣溫濕度的要求更是愈來愈嚴格，造成空調負載及空調用電的增加。
- 根據調查，目前最熱門的IC產業在同一廠房面積下，潔淨度每升高一級(如由100級升為10級)其空調耗電量約增加三倍。
- 國內空調使用率已高達90%左右，夏季時空調用電量佔總用電量之30%，於尖峰時段甚至高達41%～45%，而且空調負載每年仍以15%迅速成長。
- 若能在不影響空調品質的情況下，減少空調耗電量，即可達到空調節能的目標。

一、簡介

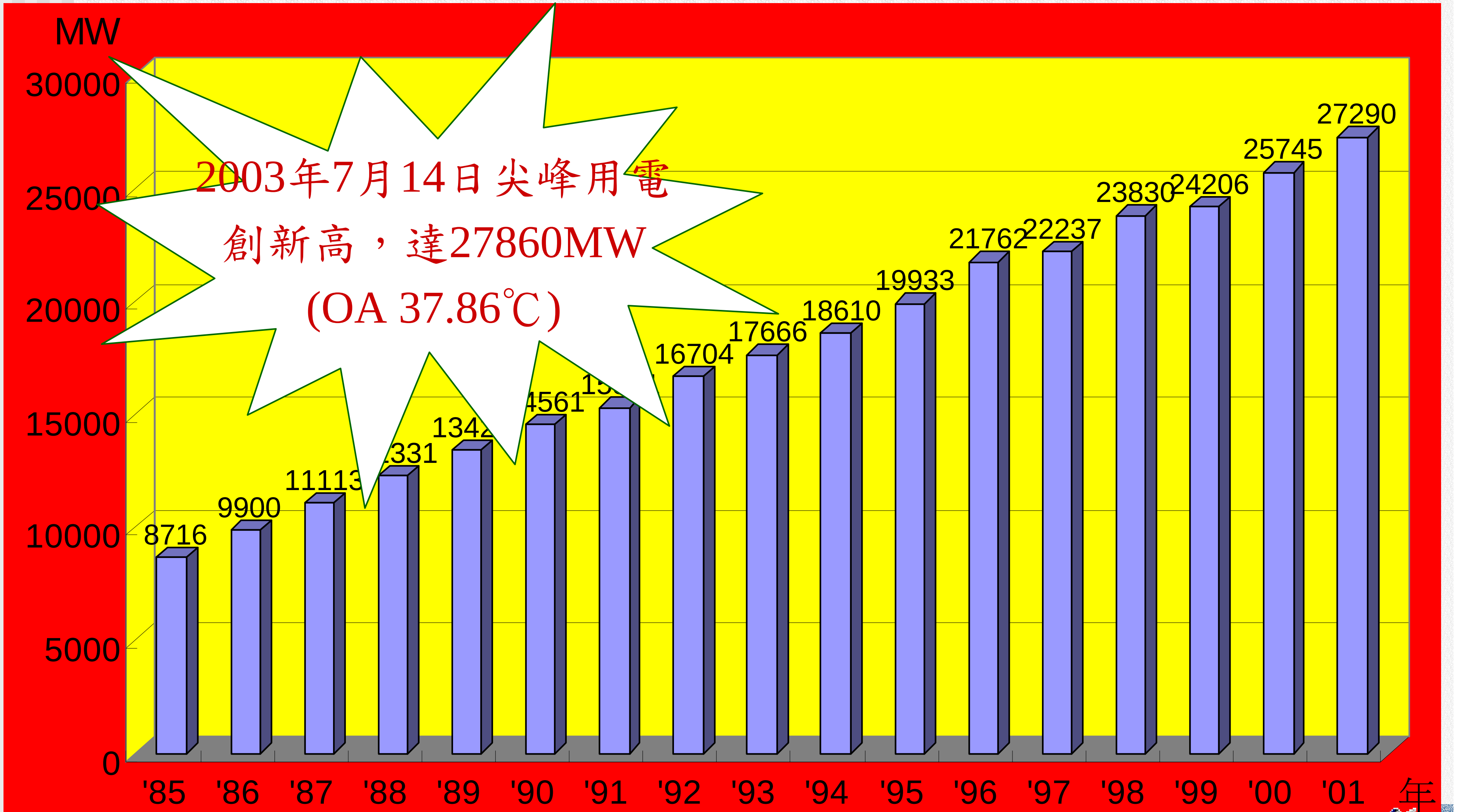
電力裝置容量圖

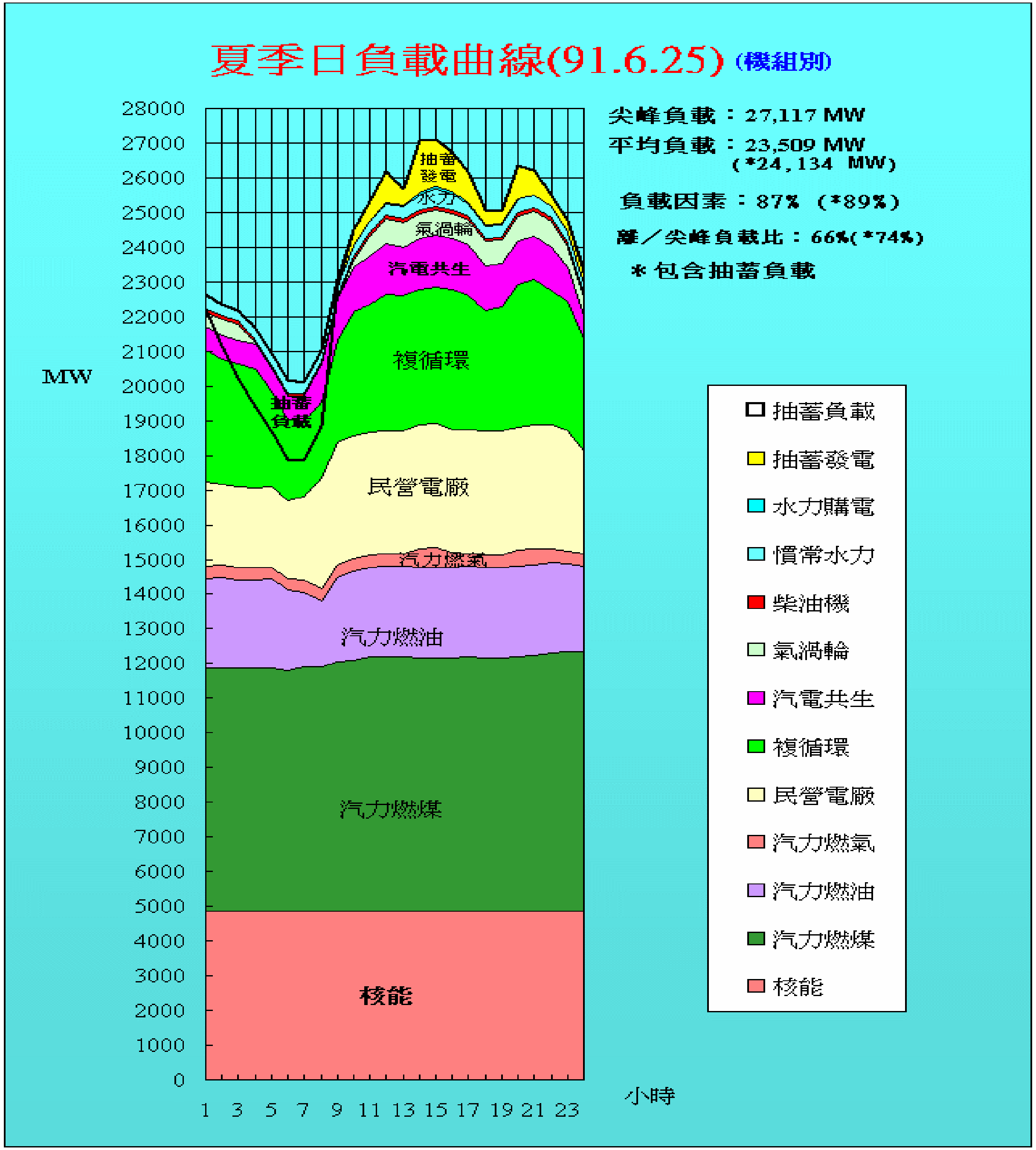


含購電
4,847 MW
MW
35000
30000
25000
20000
15000
10000
5000
0
19200
20430
21680
23,763
25,735
26,680
28,480
29,634
30,136
31,907
'93
'94
'95
'96
'97
'98
'99
'00
'01
'02
年

一、簡介

尖峰負載(Peak Load Demand)成長圖

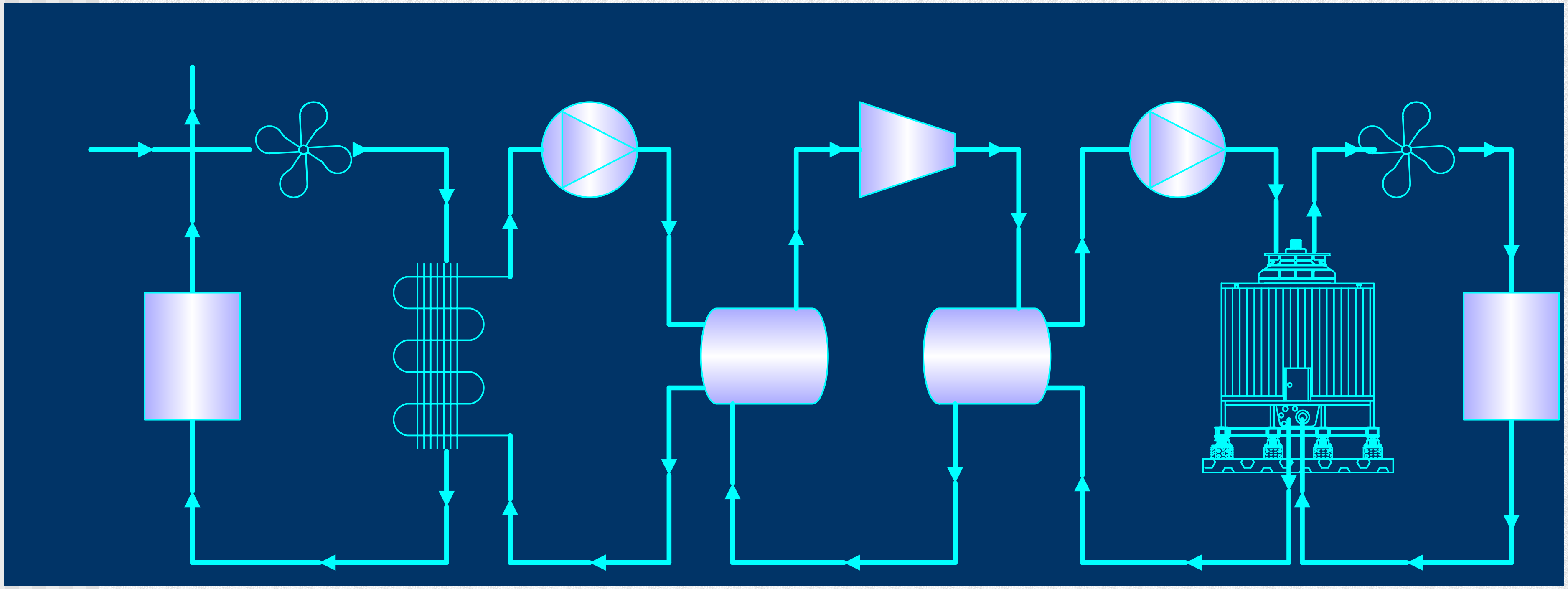




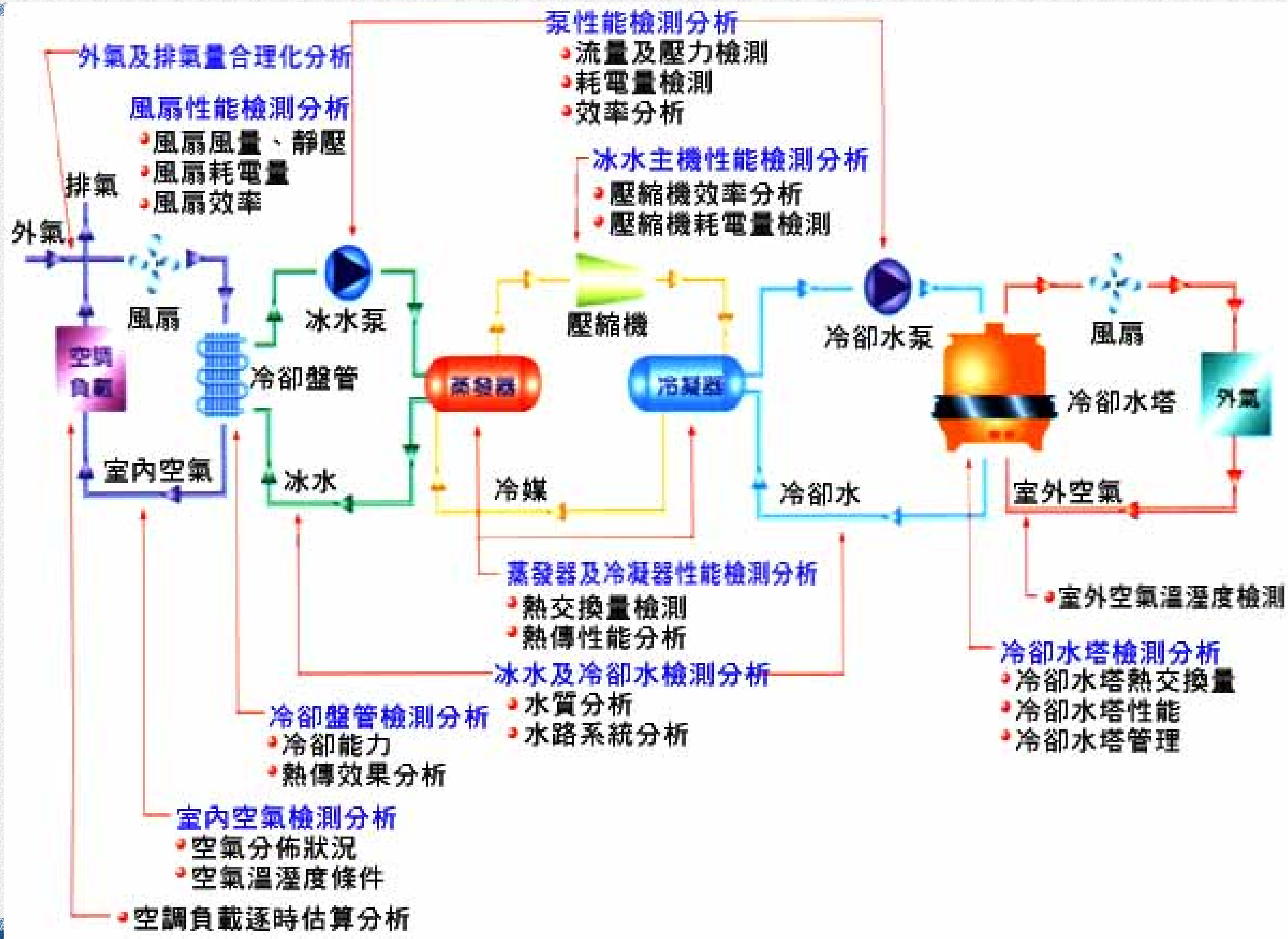
2002年6月25日之電力負載曲線圖

1-1 中央空調系統之運作

中央空調系統之五個循環



1-1 中央空調系統之運作



1-1 中央空調系統之運作

- 在互連環的愈上游(亦即愈靠近空調負載端)做節能工作則每一循環所節省下來的效益也就愈大，亦即整個系統之省能效益會是因多重節能而愈大。
- 避免空調系統太多的過大設計。過大的設計不但業主需花費較多的初設成本，同時空調系統長期處於低負載運轉，效率也差，必須付出較多的運轉成本。
- 只要能針對負載的變化調整各動件之運轉模式及部分設備更換成符合系統負載特性之高效率設備即可節省大量的電費支出。

1-2 既有中央空調系統之節能機會

- 在既有之中央空調系統中可節能之空間其實是非常大的，若做系統整體之改善，平均可節省60%左右之電力。

- 在探討節能機會時，最好能對系統效率做整體的調查與檢測(Energy Audit)，其目的有二：
  - ✓ 可了解系統耗能分佈狀況
  - ✓ 可掌握各個動件之耗電率。因此經過檢測可以較輕易地查覺出系統中節省能源之處及改善潛力。

二、空氣側節能技術

- 空氣側系統主要是由空調箱(或冷風機）、外氣及排氣風機、風管、各式風門及配件所組合而成的。
- 依據美國環保署最近對一般辦公大樓之風扇系統所作之調查顯示，超過60%的建築物其系統容量平均過大約50%，可見得具有極大之改善空間。
- 使建築物內通風/風扇系統之運作達到最佳狀態，能夠節省相關能源成本的50-85%，並且改善建築物內之環境，減少來自系統大小規劃不當所造成之風扇噪音。

2-1 HVAC空氣側節能建議

- Possible energy conservation opportunities listed in 90.1 for air side systems in buildings:
  - ✓ Equipment must be automatically scheduled off during unoccupied hours.
  - ✓ Air- or water-side economizers are required. There are several exceptions to this rule, particularly when dealing with heat recovery .
  - ✓ Reheat is allowed if at least 75% of the energy for reheat comes from on-site energy recovery (Templifiers).
  - ✓ Fan motors larger than 7½ hp on cooling towers must either have VFDs or be two speed. A control system is required to minimize power usage.

2-1 HVAC空氣側節能建議（續）

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2-1 HVAC空氣側節能建議（續）

MINIMIZING DURATION OF OPERATION

- Turn off handling systems systems when they are not needed.
- Where spaces operate on regular schedules, use timeclocks to start and stop air handling equipment.
- Install optimum-start controllers to adapt starting times to weather conditions.
- In spaces with irregular usage, install rundown timer switches to provide user control of air handling system operation.
- In spaces with irregular usage, install personnel sensors to control are handling equipment.
- Assign responsibility for operating air handling systems to the personnel who administer the spaces.

2-1 HVAC空氣側節能建議（續）

❑ OUTSIDE AIR INTAKE

- ✓ Adjust outside air intake to the minimum needed to satisfy comfort, health, and code requirements.
- ✓ During periods of reduced occupancy, control outside air dampers and exhaust fans to reduce the quantity of ventilation air appropriately.
- ✓ Control outside air intake by sensing air contaminants.
- ✓ Use air cleaning to reduce the need for outside air ventilation.
- ✓ Provide outside air economizer cycle operation of air handling units.

2-1 HVAC空氣側節能建議（續）

❑ OUTSIDE AIR INTAKE (con’t)

- ✓ Install enthalpy control of enthalpy control of economizer cycles.
- ✓ Install a purge cycle for overnight cooling.
- ✓ Install and exhaust air heat recovery system.
- ✓ Improve the envelope penetrations of air handling systems to minimize air quality problems, wind problems, and energy requirements.
- ✓ Minimize the use of extra heat for freeze protection.
- ✓ Eliminate air handling system stratification that increases energy consumption or reduces comfort.

2-1 HVAC空氣側節能建議（續）

❑ SINGLE-ZONE SYSTEMS

- ✓ Install placard at user controls to encourage efficient operation.
- ✓ If conditioning cannot be turned off during unoccupied hours, install temperature setback.
- ✓ Match fan output to the conditioning load.
- ✓ Cycle the running for the fans and other air handling system equipment with the space thermostat.
- ✓ Install multi-speed fan motors.
- ✓ Convert the system to VAV operation.

2-1 HVAC空氣側節能建議（續）

SINGLE-ZONE SYSTEMS (con't)

- ✓ Install thermostatic controls that allow space temperature to drift within comfortable limits.
- ✓ Install thermostats that require manual switching between heating and cooling.
- ✓ Install deadband thermostats.
- ✓ Adjust or modify the coil controls to increase deadband.

2-1 HVAC空氣側節能建議（續）

❑ MULTIZONE SYSTEMS

- ✓ Keep the temperature of the cold deck as high as possible and the temperature of the hot deck as low as possible.
- ✓ Install temperature rest controllers for both the cold deck and the hot deck.
- ✓ Turn off the cooling coil or the heating coil whenever practical.
- ✓ Install multi-speed fan motors.
- ✓ Convert the system to variable-air volume (VAV) operation.

2-1 HVAC空氣側節能建議（續）

- **VARIABLE-AIR-VOLUME SINGLE-DUCT SYSTEMS**
  - ✓ In spaces with shutoff VAV terminals, install thermostat placards and deadband thermostats.
  - ✓ If the air handling systems cannot be turned off during unoccupied hours, install temperature setback.
  - ✓ Minimize the minimum-flow settings of terminal units.
  - ✓ Set the cooling coil discharge at the highest temperature that maintains satisfactory cooling.
  - ✓ Install automatic chilled air temperature reset control.
  - ✓ With minimum-flow terminals, install heating/cooling changeover.
  - ✓ Improve the efficiency of fan modulation.

2-2 Fan Law

Law No.	Dependent Variables				Independent Variables
1a	Q_1	=	Q_2	×	$(D_1/D_2)^3\,(N_1/N_2)$
1b	p_1	=	p_2	×	$(D_1/D_2)^2\,(N_1/N_2)^2\,\rho_1/\rho_2$
1c	W_1	=	W_2	×	$(D_1/D_2)^5\,(N_1/N_2)^3\,\rho_1/\rho_2$
2a	Q_1	=	Q_2	×	$(D_1/D_2)^2\,(p_1/p_2)^{1/2}\,(\rho_2/\rho_1)^{1/2}$
2b	N_1	=	N_2	×	$(D_2/D_1)\,(p_1/p_2)^{1/2}\,(\rho_2/\rho_1)^{1/2}$
2c	W_1	=	W_2	×	$(D_1/D_2)^2\,(p_1/p_2)^{3/2}\,(\rho_2/\rho_1)^{1/2}$
3a	N_1	=	N_2	×	$(D_2/D_1)^3\,(Q_1/Q_2)$
3b	p_1	=	p_2	×	$(D_2/D_1)^4\,(Q_1/Q_2)^2\,\rho_1/\rho_2$
3c	W_1	=	W_2	×	$(D_2/D_1)^4\,(Q_1/Q_2)^3\,\rho_1/\rho_2$

Notes:

1. Subscript 1 denotes the variable for the fan under consideration. Subscript 2 denotes the variable for the tested fan.
2. For all fans laws $(\eta_t)_1 = (\eta_t)_2$ and $(\text{Point of rating})_1 = (\text{Point of rating})_2$.
3. p equals either p_{tf} or p_{sf}.

2-3 Reduce Heating and Cooling Loads

- 減少暖房/冷房負載之措施包括：:
  - ✓ 調整冷房/暖房室內設定溫度
  - ✓ 照明減量
  - ✓ 關閉不用之設備或燈光
  - ✓ 減少最低外氣引入量
  - ✓ 使用free cooling
  - ✓ 減少結構之暖/熱因子、控制室內空間之溫度分層

2-4 Reducing Fan Flows and Air System Resistance

Variable Air Volume (VAV)

資料來源： Shan K. Wang. 2001. Handbook of *Air-Conditioning and Refrigeration*, McGraw-Hill Professional.

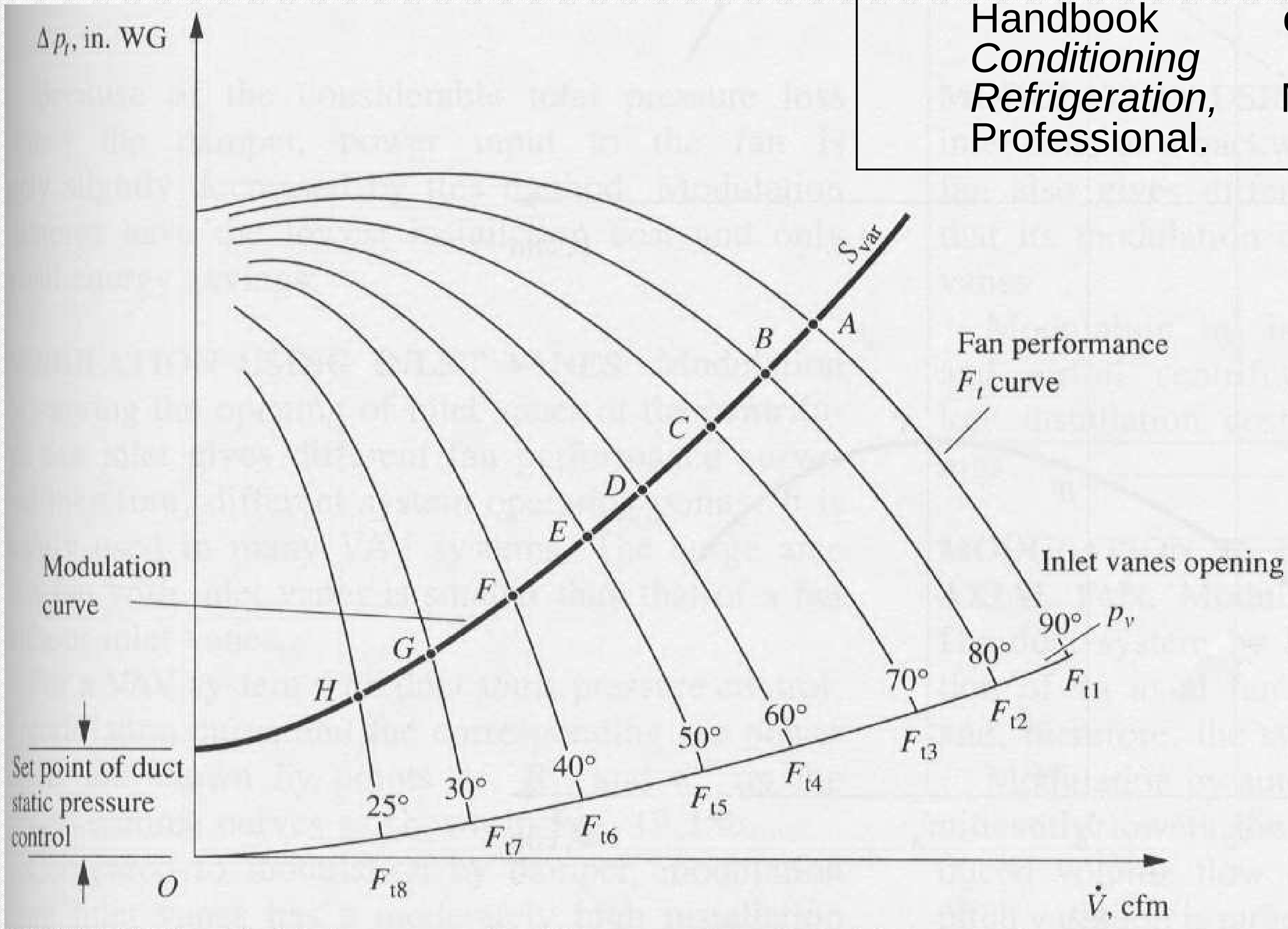


FIGURE 19.14 Modulation curve of a VAV system installed with duct static pressure control.

2-4-1 Variable Air Volume (VAV)

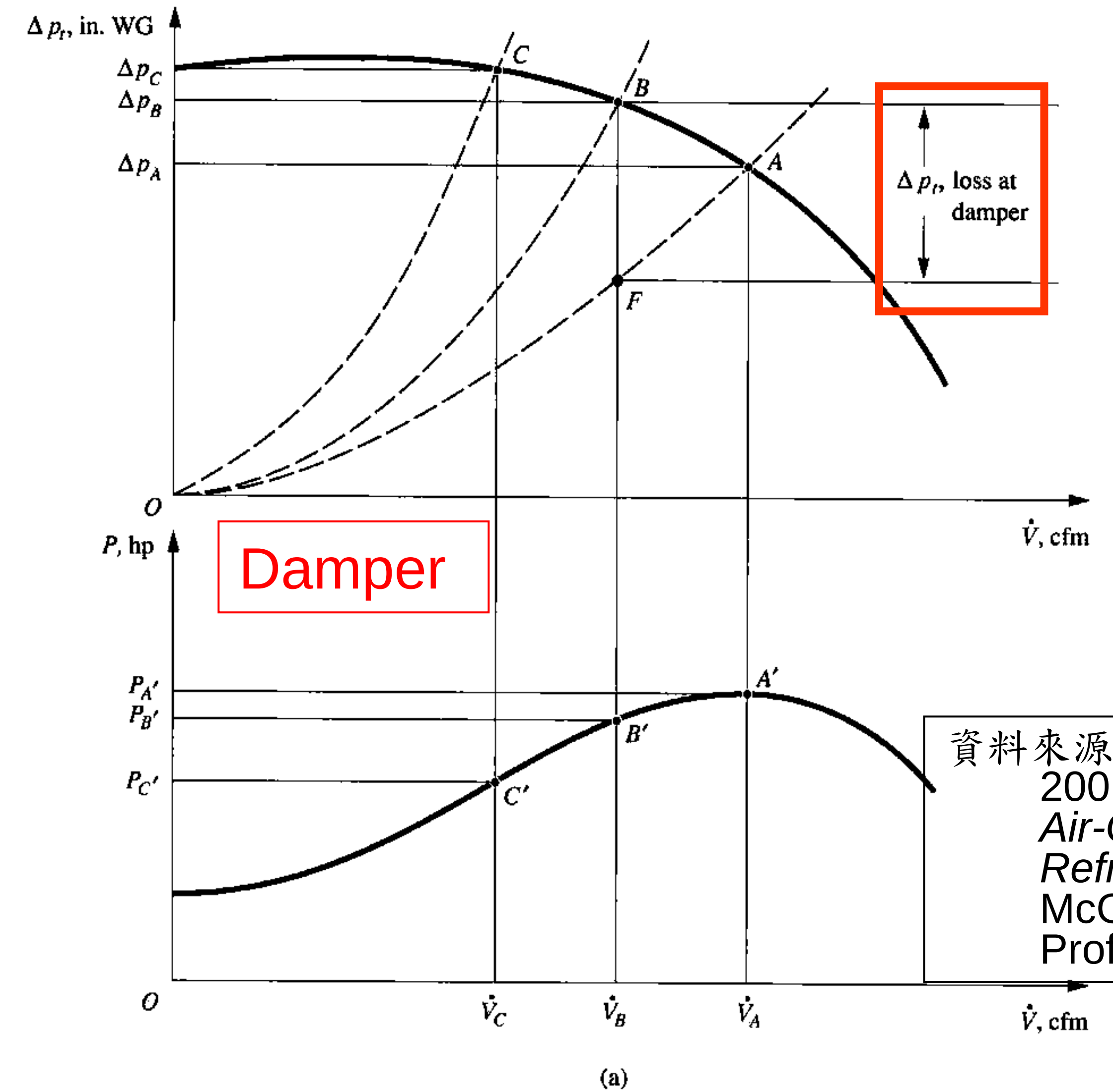


FIGURE 19.15a Modulation of fan–duct systems: (a) using dampers.

資料來源： Shan K. Wang. 2001. Handbook of *Air-Conditioning and Refrigeration*, McGraw-Hill Professional.

2-4-1 Variable Air Volume (VAV)

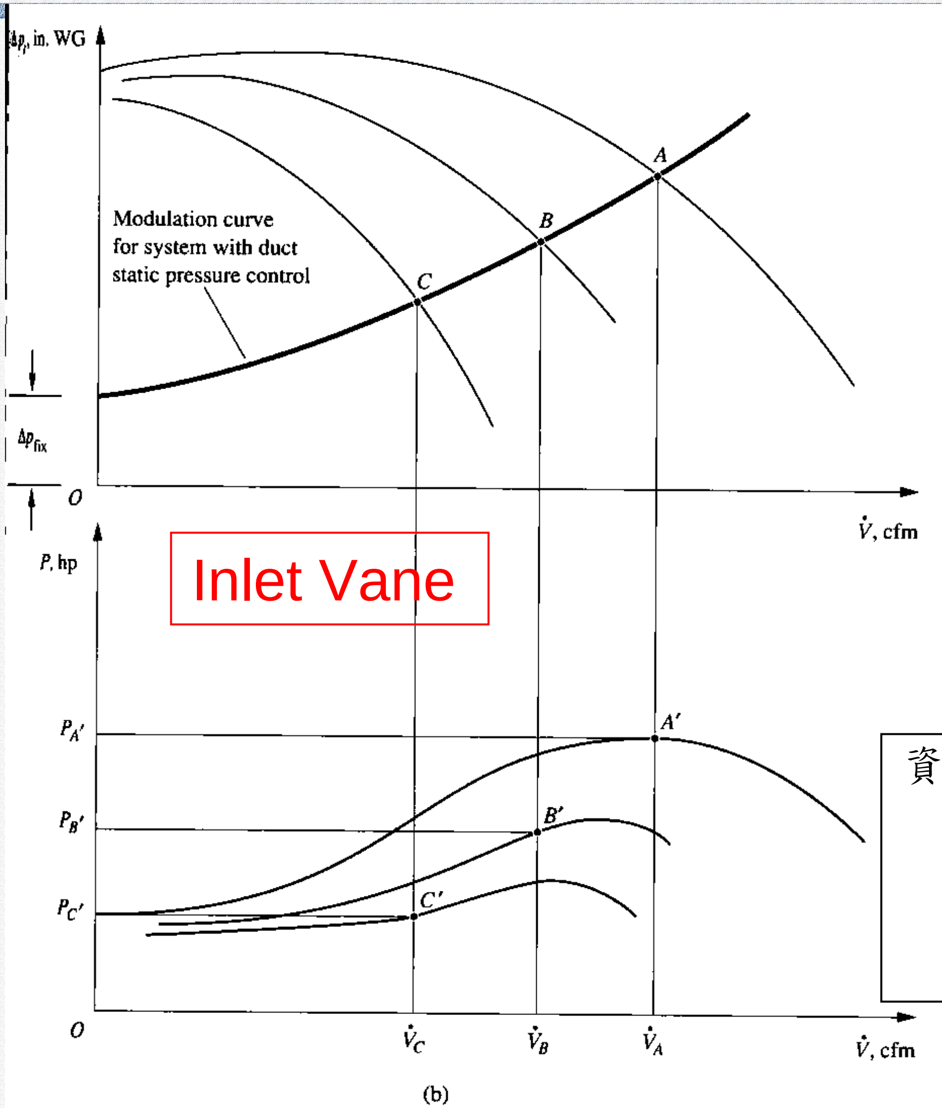


FIGURE 19.15b Modulation of fan–duct systems: (b) using inlet vanes.

資料來源： Shan K. Wang. 2001. Handbook of *Air-Conditioning and Refrigeration*, McGraw-Hill Professional.

2-4-1 Variable Air Volume (VAV)

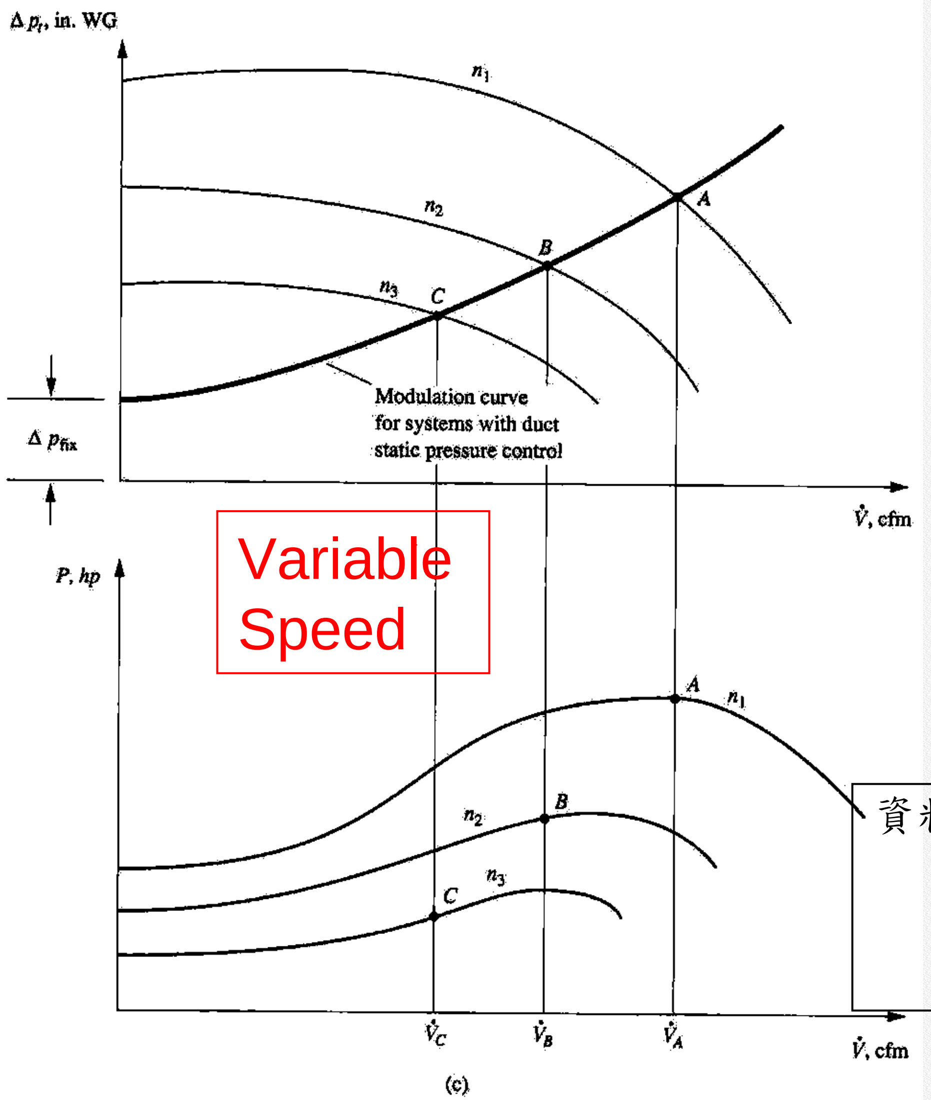


FIGURE 19.15c Modulation of fan–duct systems: (c) using an AC inverter to vary fan speed.

Variable Speed

資料來源： Shan K. Wang. 2001. Handbook of *Air-Conditioning and Refrigeration*, McGraw-Hill Professional.

2-4-1 Variable Air Volume (VAV)

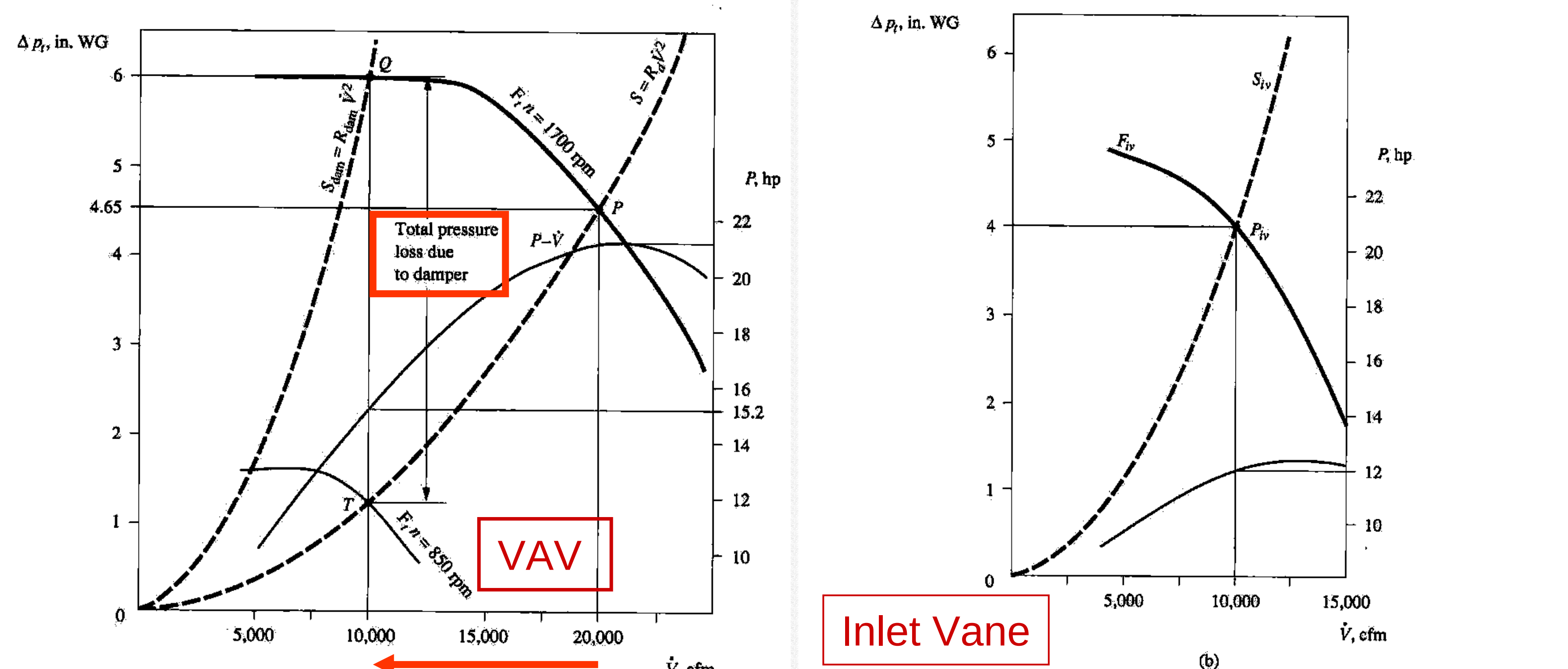
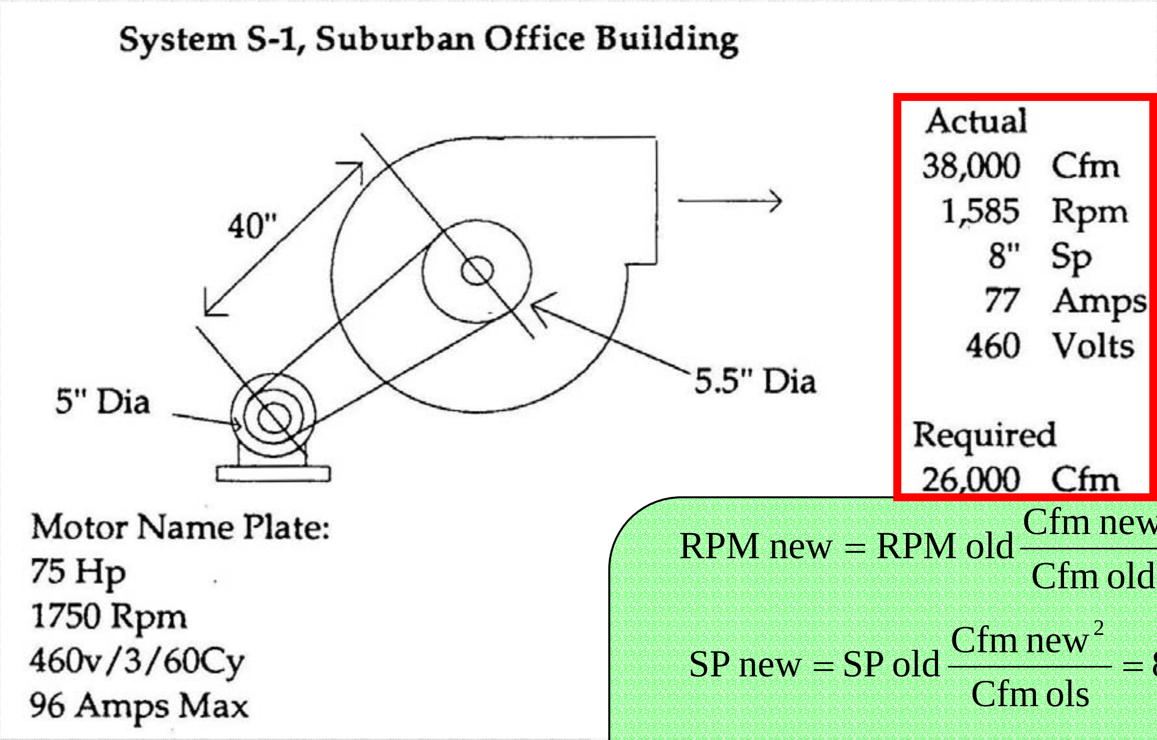


FIGURE 19.16 Modulation of a VAV system using dampers, inlet vanes, and fan speed variation: (a) using dampers and fan speed variation and (b) using inlet vanes.

資料來源： Shan K. Wang. 2001. Handbook of *Air-Conditioning and Refrigeration,* McGraw-Hill Professional.

2-4-2 Example 1

- Calculate New Fan Performance



$$\text{RPM new} = \text{RPM old}\frac{\text{Cfm new}}{\text{Cfm old}} = 1{,}585 \times \frac{26{,}000}{38{,}000} = 1110\ \text{RPM}$$

$$\text{SP new} = \text{SP old}\frac{\text{Cfm new}^2}{\text{Cfm ols}} = 8'' \times \frac{26{,}000}{38{,}000} = 4.1''\text{SP}$$

$$\text{Bhp atual} = (\text{HP}) \times \frac{\text{Amps act}}{\text{Amps rated}} \times \frac{\text{Volts act}}{\text{Volts rated}} \frac{77}{96} \times \frac{460\text{V}}{460\text{V}} = 59\ \text{Bhp}$$

$$\text{Bhp new} = \text{Bhp old} \times \frac{\text{Cfm new}^3}{\text{Cfm old}} = 59 \times \frac{26{,}000^3}{38{,}000} = 19\ \text{Bhp}$$

資料來源： Herb Wendes. 1994. *HVAC Retrofits. Energy Savings Made Easy*, The Fairmont Press, INC.

2-4-2 Example 1

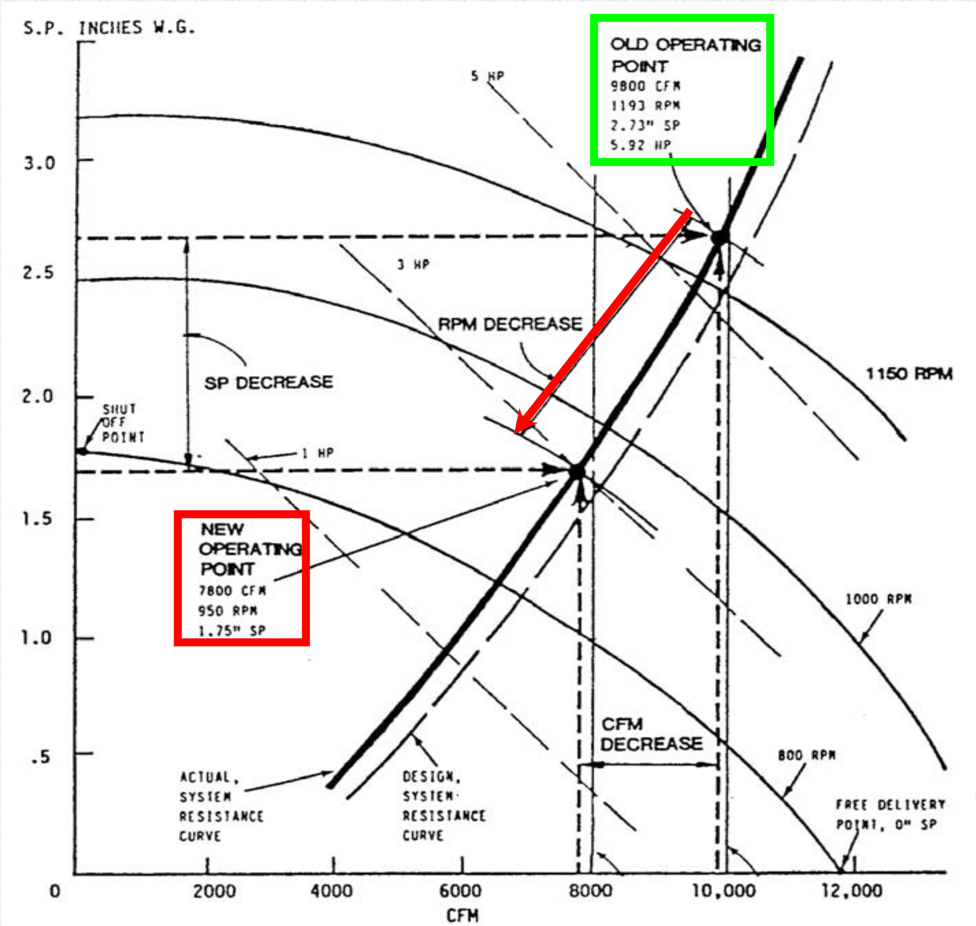
$$\text{Bhp atual} = (\text{HP}) \times \frac{\text{Amps act}}{\text{Amps rated}} \times \frac{\text{Volts act}}{\text{Volts rated}} = \frac{77}{96} \times \frac{460\text{V}}{460\text{V}} = 59\ \text{Bhp}$$

$$\text{Bhp new} = \text{Bhp old} \times \frac{\text{Cfm new}^3}{\text{Cfm old}^3} = 59 \times \frac{26{,}000^3}{38{,}000^3} = 19\ \text{Bhp}$$

- 如果新電流運轉數小於最低操作電流，即低於滿載電流之40%，則基於節能考量，最好更換小一點之馬達，同時可考慮高效率之馬達。

2-4-2 Example 2

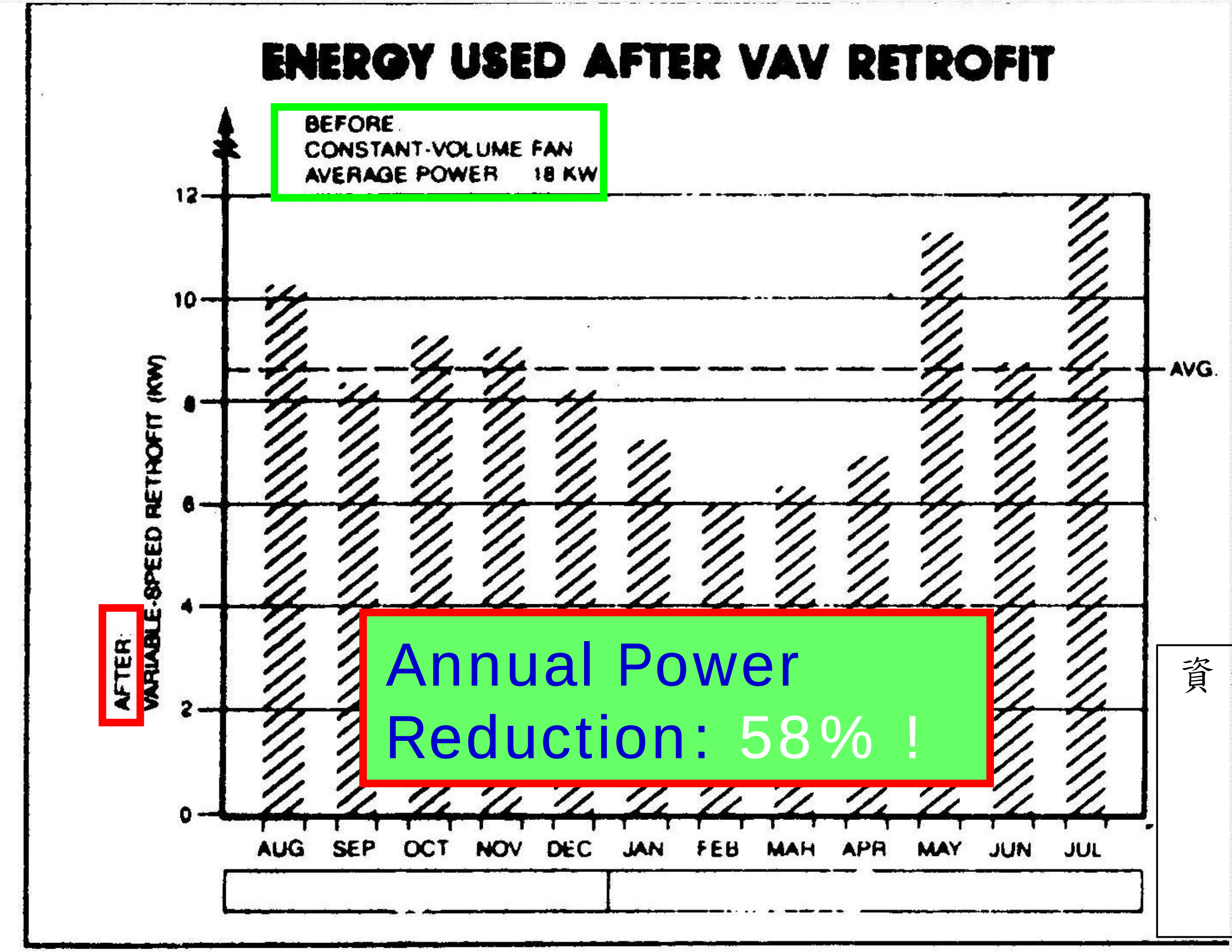
- Simple Fan Curve Reducing Air Flow



資料來源： Herb Wendes. 1994. *HVAC Retrofits. Energy Savings Made Easy*, The Fairmont Press, INC.

2-4-2 Example 3

- Energy Used After VAV Retrofit



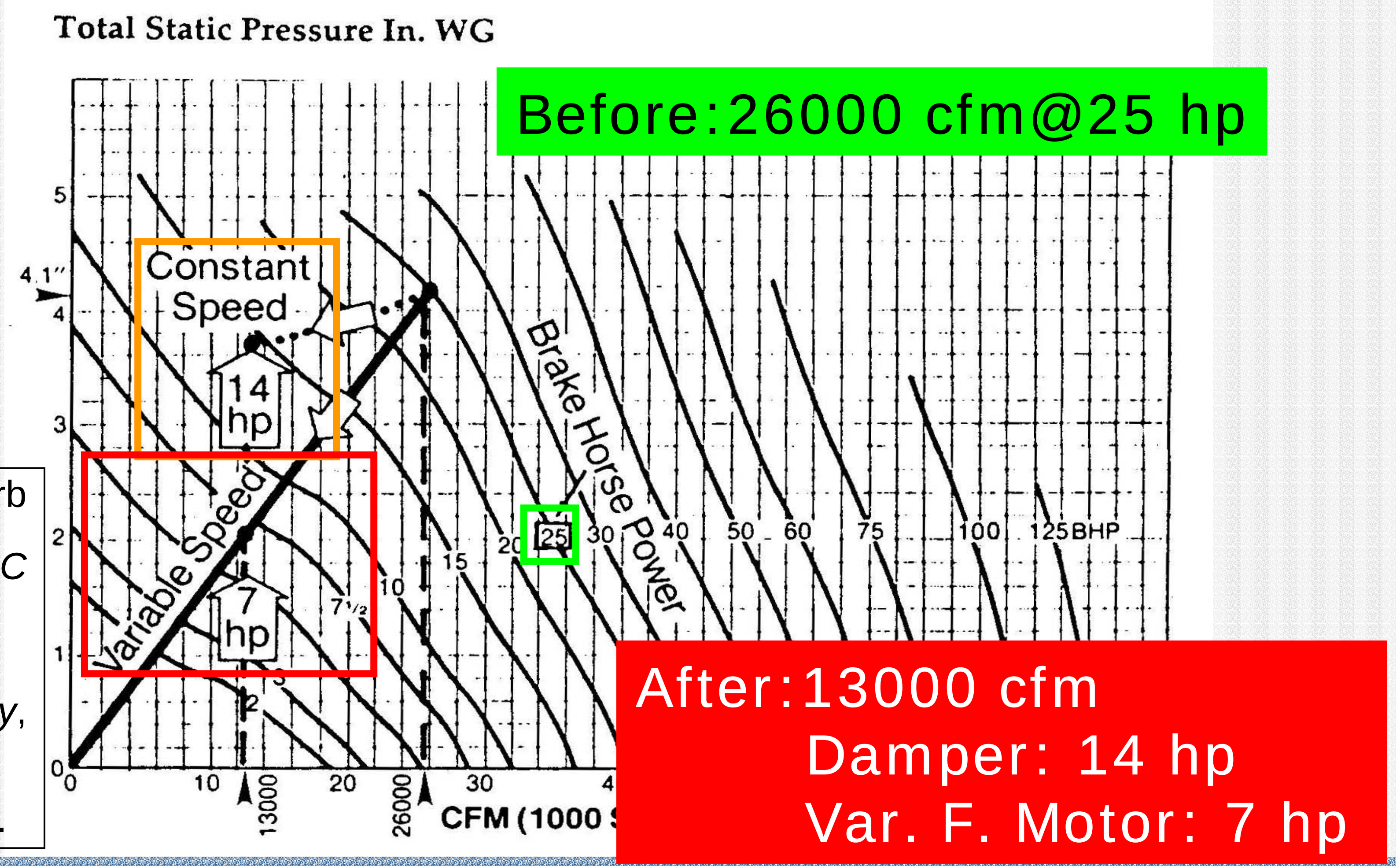
資料來源： Herb Wendes. 1994. *HVAC Retrofits. Energy Savings Made Easy*, The Fairmont Press, INC.

2-4-2 Example 3

- 上圖可看出，原20 hp，平均耗電18kW之定風量系統若改為變轉速之變風量系統，則每個月都可減低耗電量。依據量得之數據，一年可節省36,000 kWh電量，減少58%之耗電。

2-4-2 Example 4

- Inlet Vane and Motor Speed Controller BHP



資料來源： Herb Wendes. 1994. *HVAC Retrofits. Energy Savings Made Easy*, The Fairmont Press, INC.

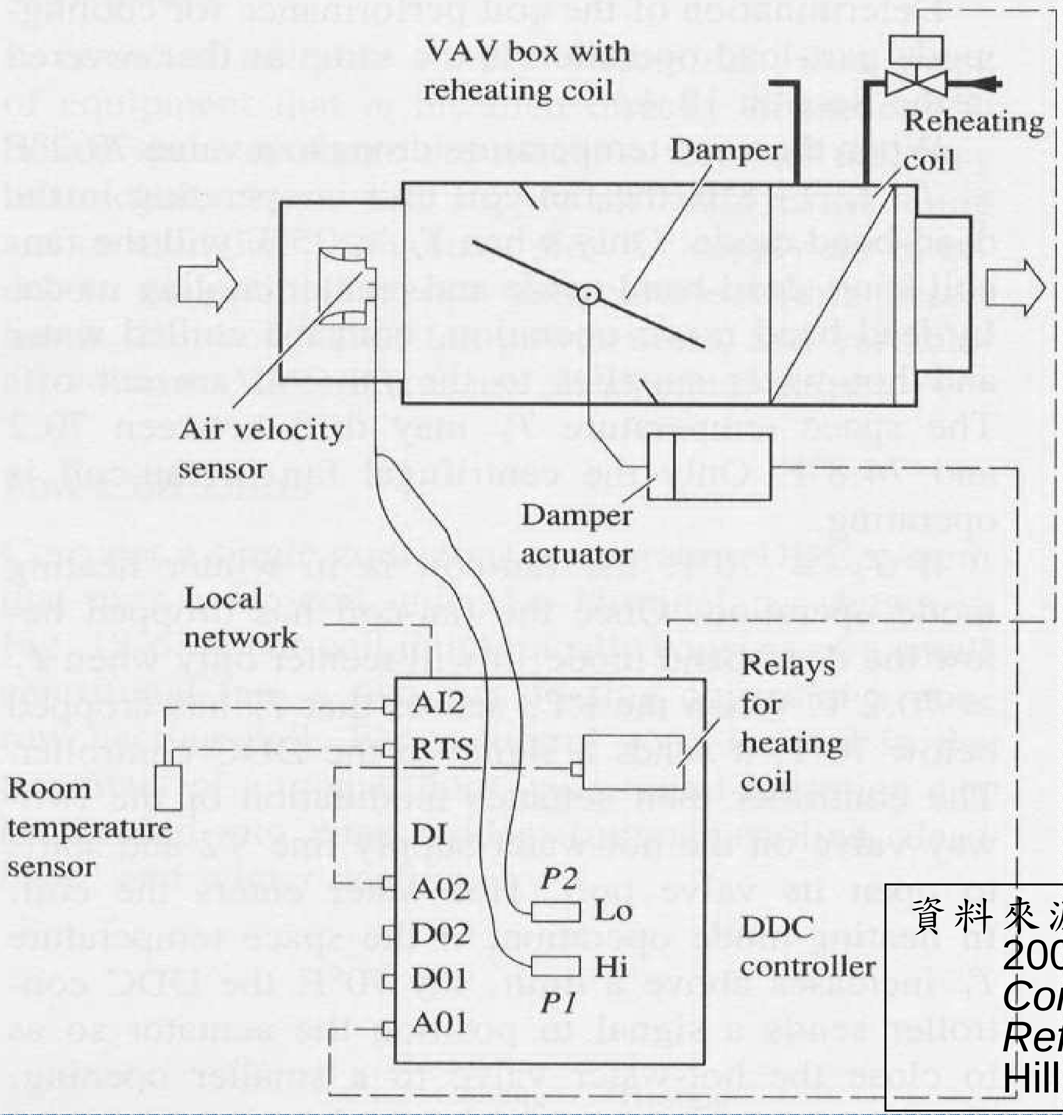
2-5 Fan-Coil Unit

- 對F/C而言，其之送風距離短，外氣一般而言只有送風量之20%， 故使用風機盤管會有較低之送風耗能。
- 對風機盤管而言，其節約能源之潛力有兩方面：
  1. 依需要或用溫度來調節冰水量，以節約水泵之耗能。
  2. 一般而言，風機盤管之風車有三速控制，但研究發現馬達之控制未如理想，無法達到有效及節能變速之目的。
  3. 為了節能，馬達可裝置無段變速控制，最佳為30-100%風量之控制，如此不但可節約能源，並可增加空調之溫度及舒適度控制效果。
  4. 一般而言，空調之負載多在50%左右，故無段變速之節能效果能節省20至30%之耗能。

2-6 All Air System

- 另一種常用的空調送風系統為全空氣系統。這種空調方式的特點為：
  - 空氣較集中處理，可獲得較佳空調(如溫濕度控制、清淨度等)
  - 設備集中，較易維護。
  - 其缺點為風管長度較長，送風耗能大。解決耗能的方法為使用VAV 空調系統，其可節省大量的送風耗能
- VAV 系統中用溫度和壓力的感測器（transmitter），偵測風管內溫度及壓力的改變，然後將訊息傳給接收控制器（receiver controller），以控制風門和風扇的進氣量及冷盤管的冷水量來節約能源。其詳細的控制程序如下：

2-6 All Air System



資料來源： Shan K. Wang. 2001. Handbook of *Air-Conditioning and Refrigeration*, McGraw-Hill Professional.

2-8 通風/風扇系統節能策略

1. 決定風扇系統之大小是否適中
   - ✓ 對可變風量系統，可先測量最大冷卻負載（潮濕炎熱之夏天）時之風扇馬達電流。如果低於馬達標示全載電流之75%或是風扇控制閥之關閉度大於20%時，表示風扇功率過大。
   - ✓ 對定風量系統，則可測量系統最大負載下之靜壓（static pressure），若超過設計值則表示風扇功率過大，需要進行改善工作。
2. 升級大小不適宜之風扇系統

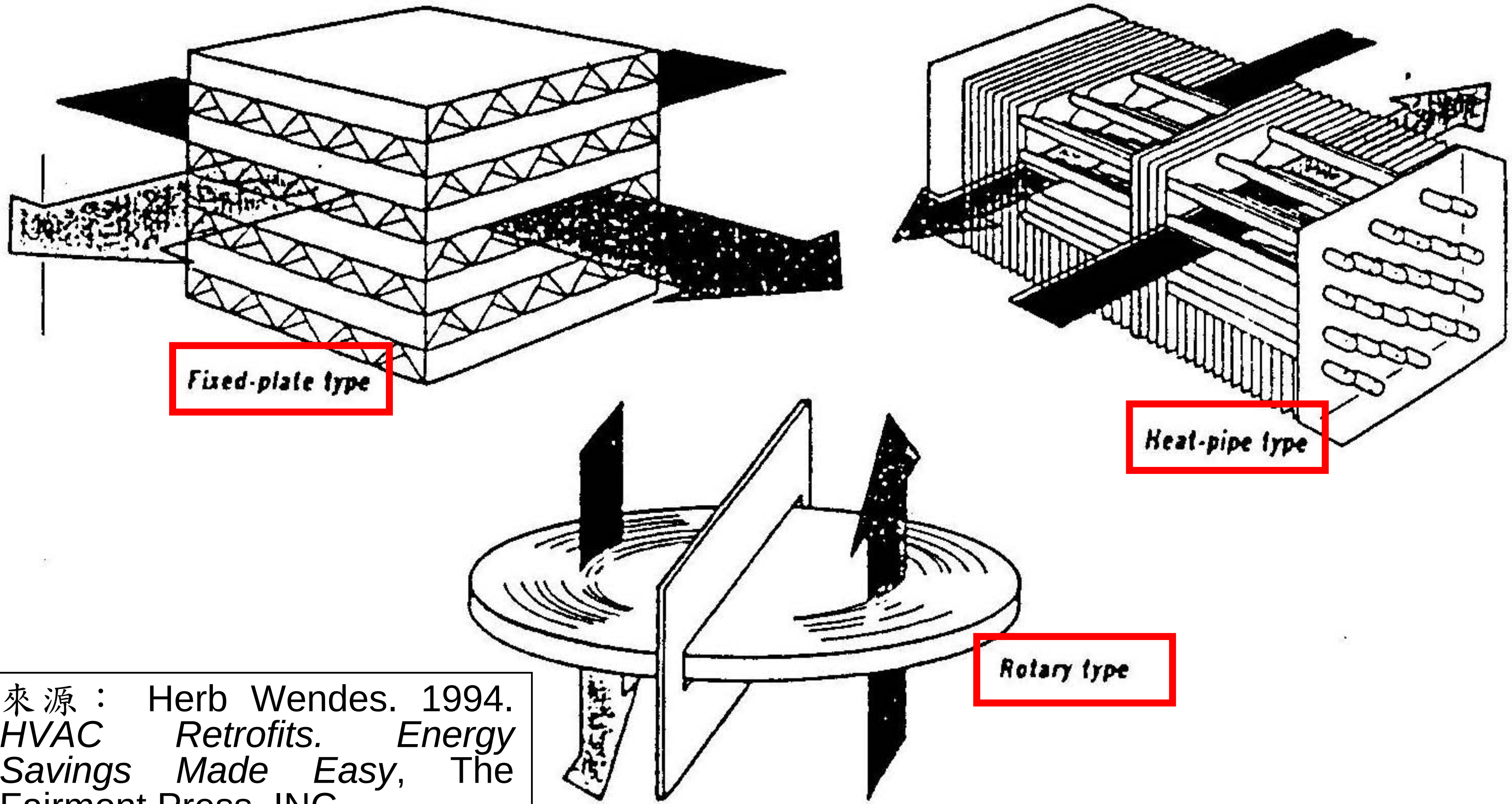
   風扇功率過大時，可以採用下列三種方式來改進：
   - ✓ 使用較小較具效率之馬達
   - ✓ 採用較大尺寸之傳動帶系統，以減少馬達轉速
   - ✓ 調整靜止風壓。可變風量系統要達到最大效率時，必須要與可變速馬達配合使用

2-8 通風/風扇系統節能策略

3. 改善通風系統之使用時程與控制方式
4. 裝設具能源效率之風扇馬達
   - ✓ 一般馬達之能源效率隨功率不同介於75%-95%之間。
   - ✓ 高效率馬達與標準效率馬達可能具有5%之能源效率差異。。
   - ✓ 注意馬達皮帶傳動系統之傳動帶更換與選用較具效率之傳動系統，亦有助改善能源效率。

2-9 Heat Recovery

- Ways to Recover Heat



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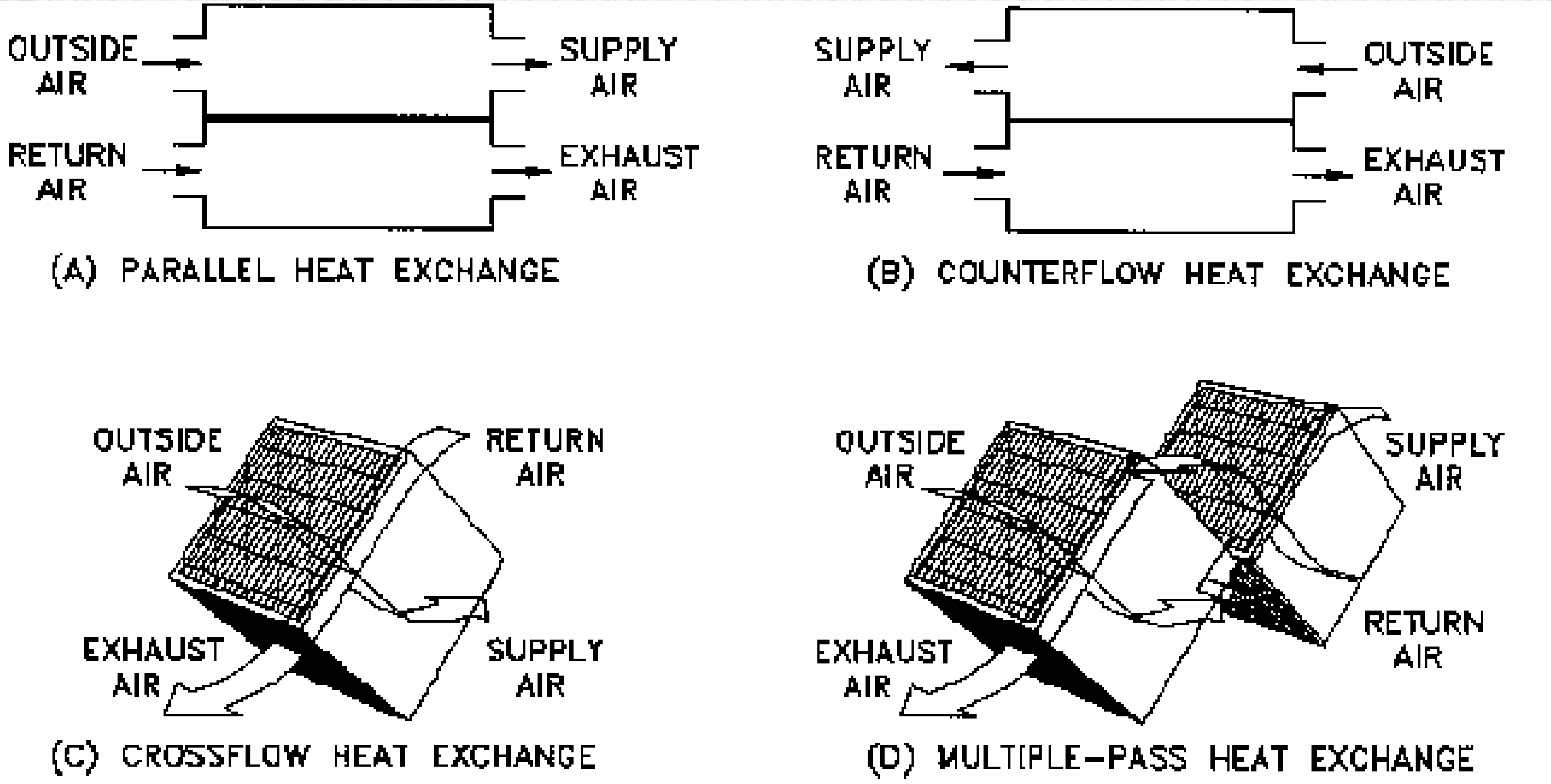
2-9 Heat Recovery



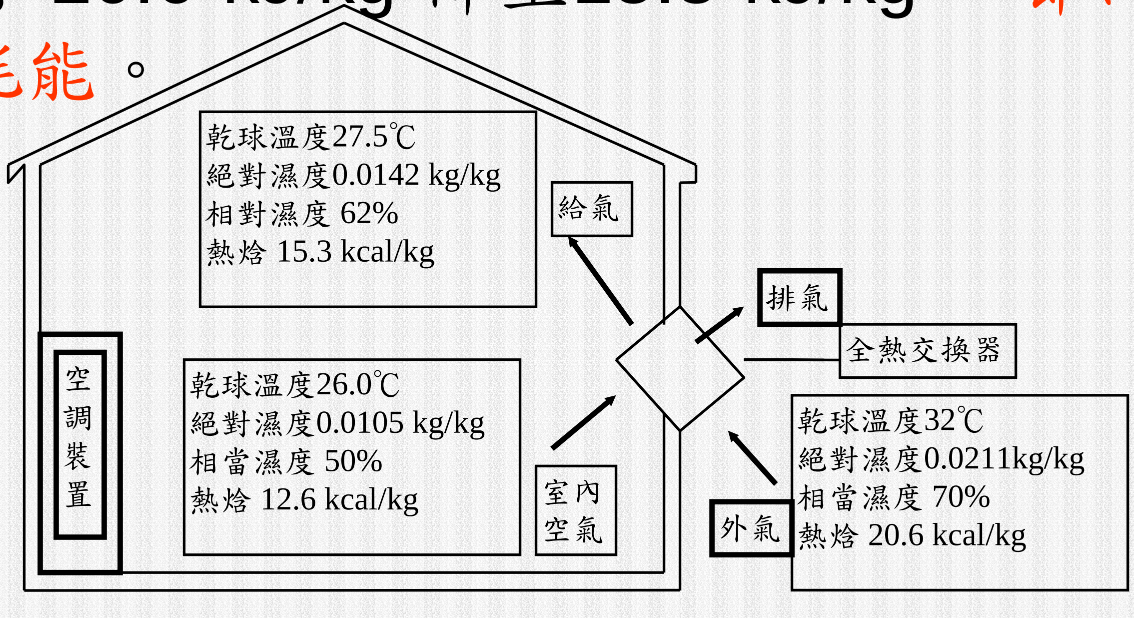
資料來源： ASHRAE. 2003. *HVAC Systems and Equipment*.

2-9 Heat Recovery

- 全熱交換器基本上有兩種，一為靜態之交叉流式，另一為轉輪式，操作原理及應用可簡述如下：
  - ✓ 靜態交叉流式之全熱交換器內有許多平板之流道，以隔板與密封裝置將兩股流分開在每個平板之兩側，流向為交叉方向。平板多以可滲透之纖維製成，一邊吸收之水就可以滲透到另一邊讓另一股流帶出全熱交換器。這種設備本身不須有動力，維護簡單，為其主要優點。
  - ✓ 轉輪式：需用一個小馬達造成這種蜂巢輪之轉動，轉輪式之優點為交換效率高，適用於較大型或外氣集中處理之系統如用於中央空調之空調箱。全熱交換器可與小型空調系統配合使用，可以達到省能又維持高新鮮空氣之目的。

2-9 Heat Recovery

- 熱回收之設計例：用一個全熱交換器，使外氣進入室內前將其水蒸汽與熱吸收，使進入之外氣降溫降濕；排氣亦先流經全熱交換器，把濕氣與熱帶到室外。在 70% 之交換效率下，可將外氣焓值自 20.6 kJ/kg 降至15.3 kJ/kg ，節約70%之外氣耗能。



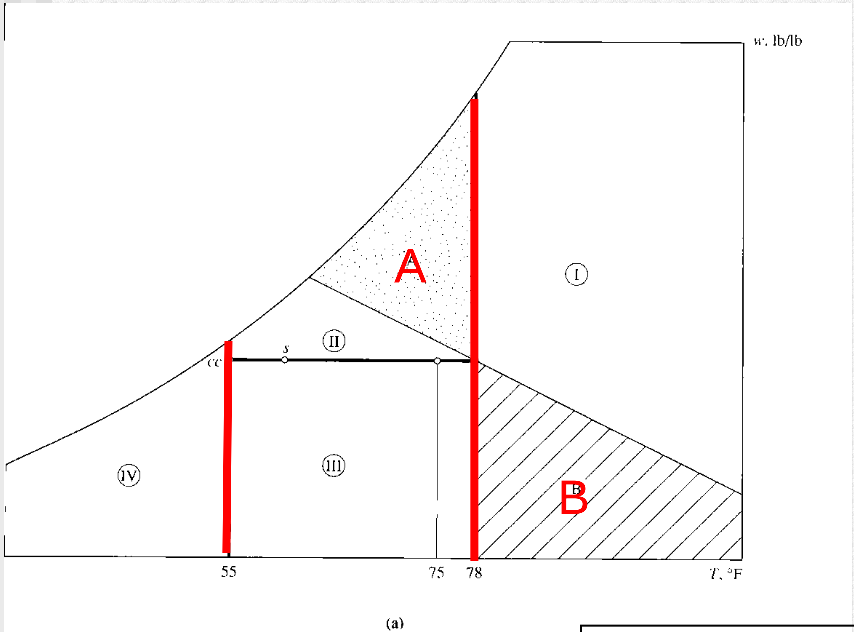
交叉流式全熱交換器之應用

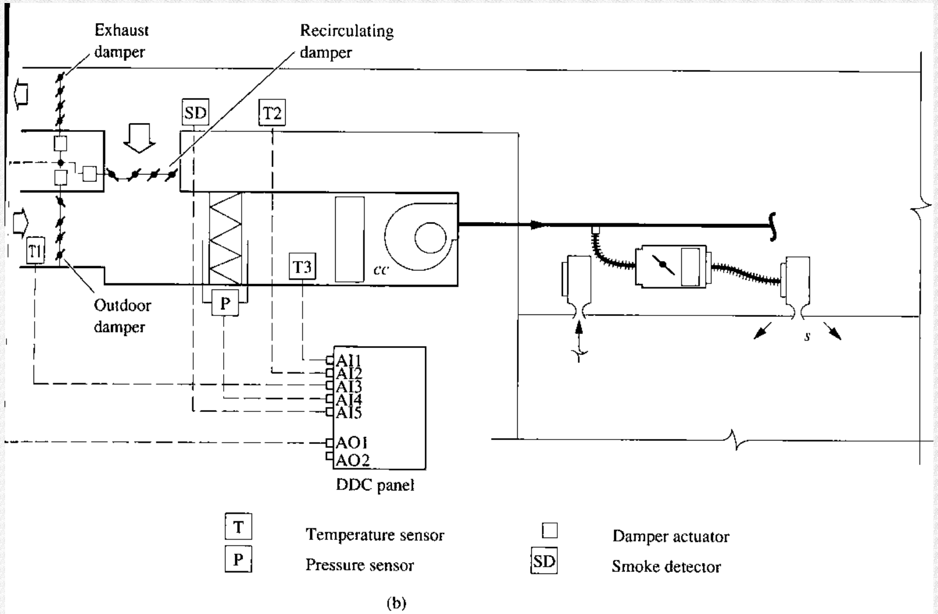
2-10 Economizer

2-10-1 Air Economizer

- Temperature air economizer control

(a)outside weather regions (b)temperature air economizer



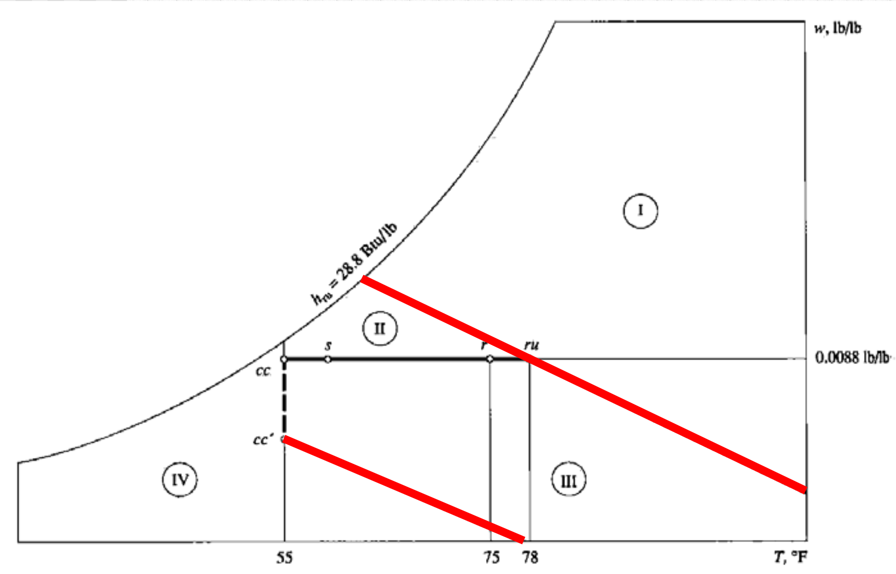


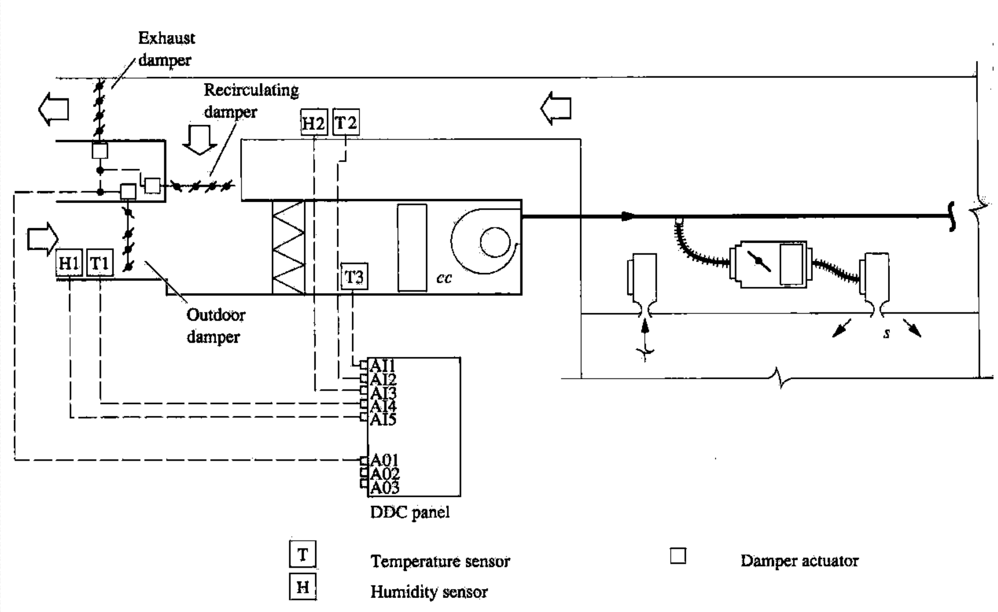
資料來源： Shan K. Wang. 2001. Handbook of *Air-Conditioning and Refrigeration*, McGraw-Hill Professional.

2-10-1 Air Economizer

- Enthalpy air economizer control

(a)outside weather regions (b) enthalpy air economizer





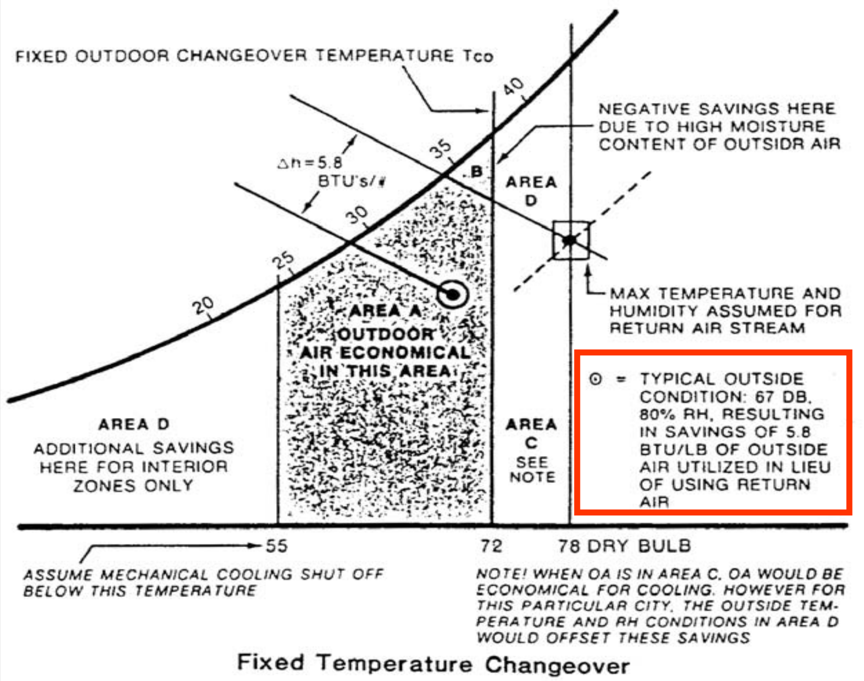
資料來源： Shan K. Wang. 2001. Handbook of *Air-Conditioning and Refrigeration*, McGraw-Hill Professional.

2-10-3 Advantages of Using Economizers

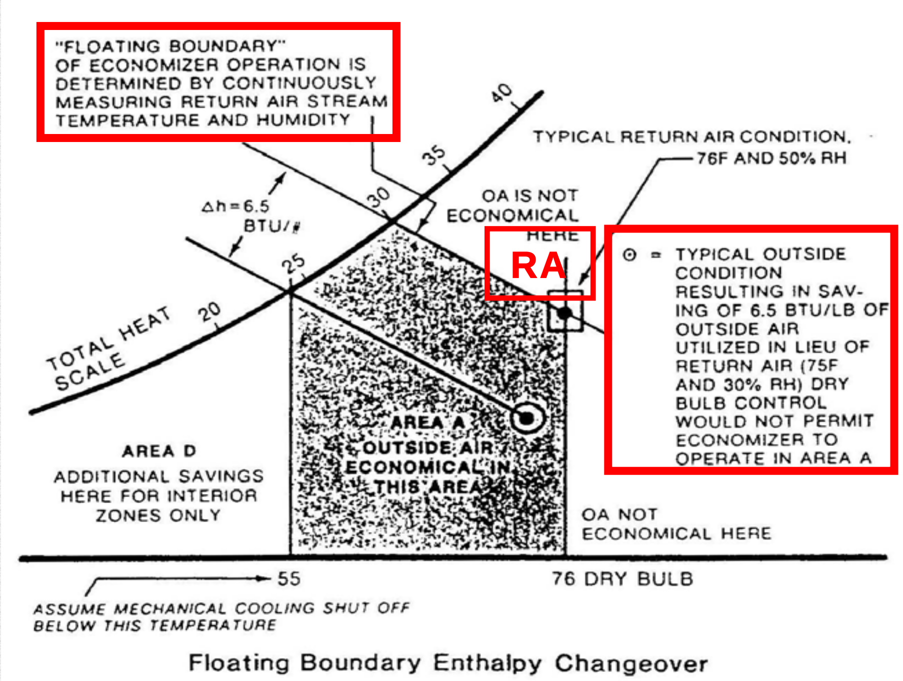
- 無論使用 Air Economizer 或 Water Economizer，都可比不使用Economizer節能15%~40%！

2-11 Free Cooling

- Analysis of Using Outside Air For Free Cooling



Fixed Temperature Changeover



Floating Boundary Enthalpy Changeover

資料來源： Herb Wendes. 1994. *HVAC Retrofits. Energy Savings Made Easy*, The Fairmont Press, INC.

2-11 Free Cooling

- 欲使用free cooling降低系統負荷，ASHRAE/IES Standard 90.1-1989指定每一空氣系統必須包含下列任一項：
  - ✓ 使用temperature或enthalpy air economizer提供設計外氣與循環空氣引入量之85%以上。
  - ✓ 使用直接-間接蒸發式冷卻之water economizer在外氣乾球溫度10℃(50°F)、濕球溫度7℃(45°F)（或低於此狀態）時，必須能夠完全供應系統冷能。

三、室內空氣分佈--節能與舒適度

3-1 供風空氣條件考量：

- ✓ 低溫送風？
- ✓ 最佳送風溫度？

3-2 可變風量對室內氣流分佈之影響

- ✓ 室內氣流與舒適度
- ✓ VAV改裝效益

3-3 室內空氣品質與空調節能

- ✓ 相互抵觸？
- ✓ TB, SARS or .....
- ✓ 對策

3-1 供風空氣條件考量

Cold Air Distribution

- Cold-air distribution systems supply air for space conditioning at reduced temperatures, sometimes referred to as low-temperature air distribution systems.
- Typically supply air between 4°C and 10°C.
- Conventional supply air at nominal temperatures between 10°C and 15°C.
- The use of cold-air distribution technology can result in lower mechanical system costs, reduced energy consumption, and improved comfort.

3-1.1 低溫送風

- With the 1°C to 4°C chilled fluid temperatures available from ice storage, supply air temperatures of 4°C to 9°C could now be easily achieved.
- Allowing significant savings in air distribution system costs and energy consumption.
- Improvements in occupant comfort at reduced relative humidity levels were also recognized.

3-1.1 低溫送風

- There are some applications where cold-air distribution should be used with caution:
  - Generation of chilled fluid at 34°F to 40°F (1°C to 4°C) is not practical,
  - Space relative humidity must be maintained above 40%,
  - High volumes of ventilation air are required, or
  - Economizer cooling is available with outdoor temperatures of 45°F to 55°F (7°C to 13°C) for many hours of the year.
- Avoid dumping and air outlet condensation.

3-1.2 最佳送風溫度

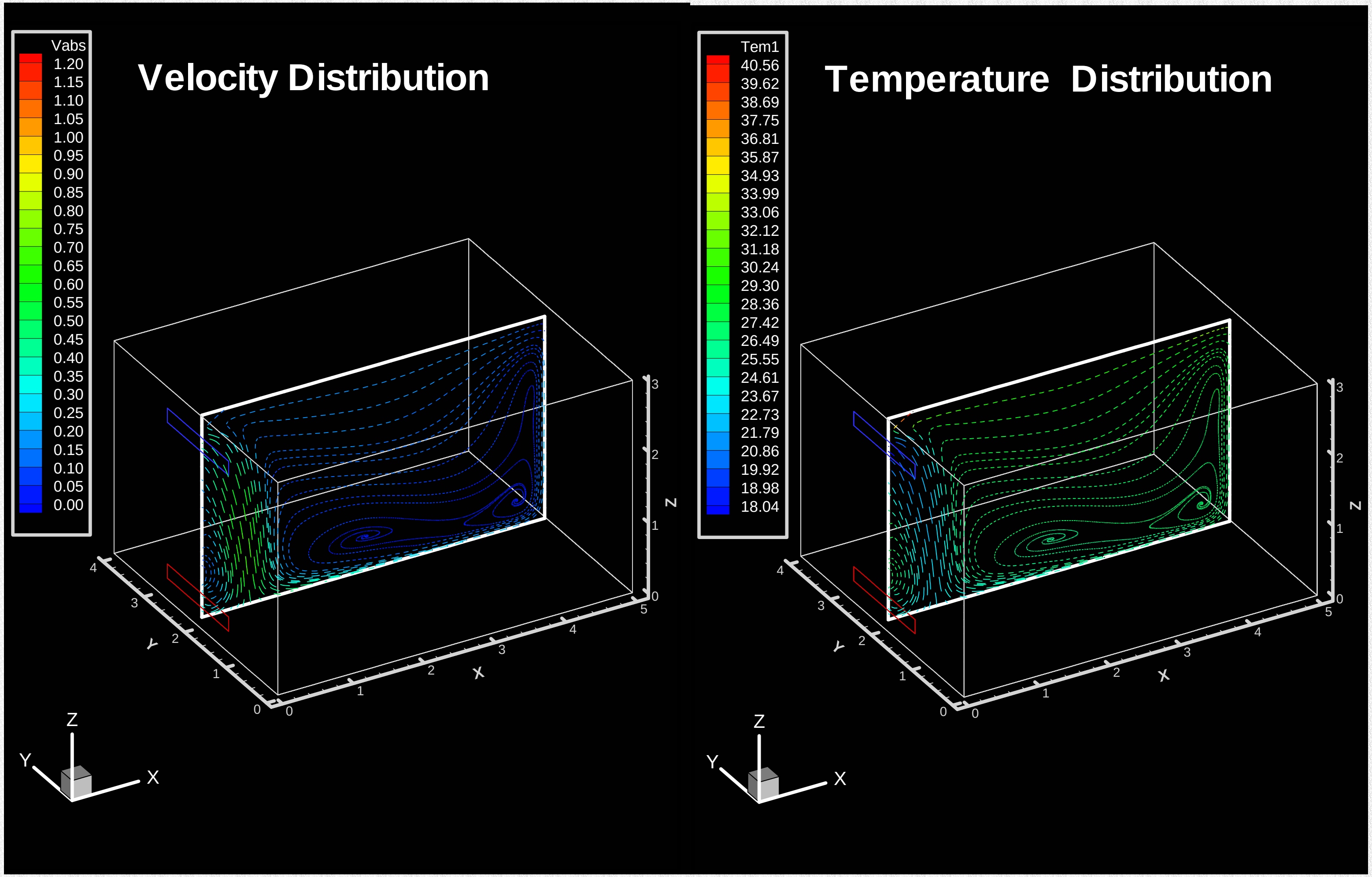
- 低溫送風系統造成出風口結露及空間濕度過低之不利影響。
- 若送風溫度能調整至約7℃~11℃，應為最佳化節能出風溫度，將可減少設備初設費用和改善濕度控制。
  - ✓ 可廣泛地使用於百貨商場，辦公大樓和學校等，最佳風溫系統，年度能源使用量並不會比傳統的系統高，有值得推廣的空間。

3-1.2 最佳送風溫度

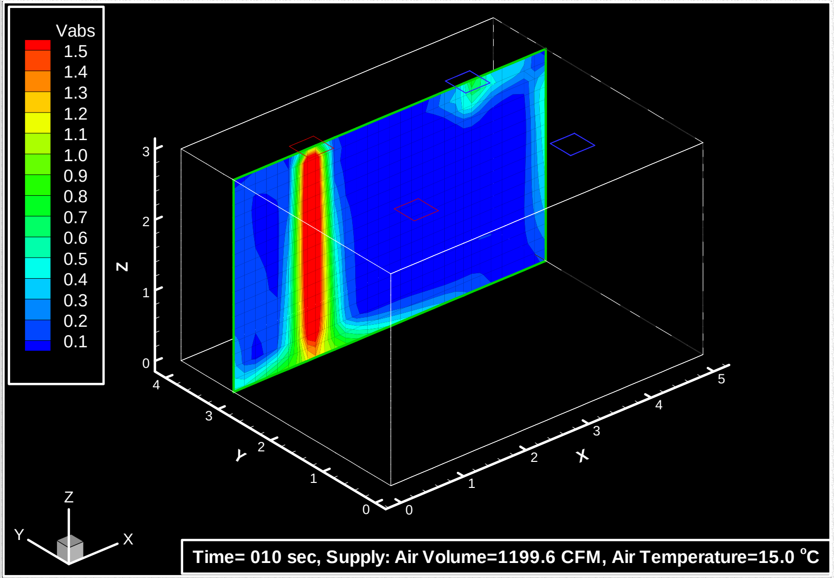
SAT °F	TSP inches w.c.	Supply Air Volume cfm	Design Cooling Tons	CWST °F	Perform-ance kW/ton	Room Setpoint °F	Chiller Work kWh/yr	Fan Work kWh/yr	Total Work kWh/yr
55	3.00	152,686	473	44.0	0.550	75	219,605	202,736	422,341
54	3.02	145,415	475	43.6	0.554	75	226,594	194,061	420,655
53	3.04	138,805	477	43.2	0.558	75	236,352	186,175	422,527
52	3.06	132,770	479	42.8	0.562	75	241,228	178,975	420,203
51	3.08	127,238	481	42.4	0.566	75	248,661	172,375	421,036
50	3.10	122,149	483	42.0	0.570	75	255,777	166,303	422,080
49	3.12	117,451	485	41.6	0.574	75	261,285	160,698	421,983
48	3.14	113,101	486	41.2	0.578	75	269,044	155,508	424,552
47	3.16	109,061	488	40.8	0.582	75	276,512	150,689	427,201
46	3.18	105,301	490	40.4	0.586	75	286,605	146,202	432,807
45	3.20	101,791	492	40.0	0.590	75	292,832	142,014	434,846

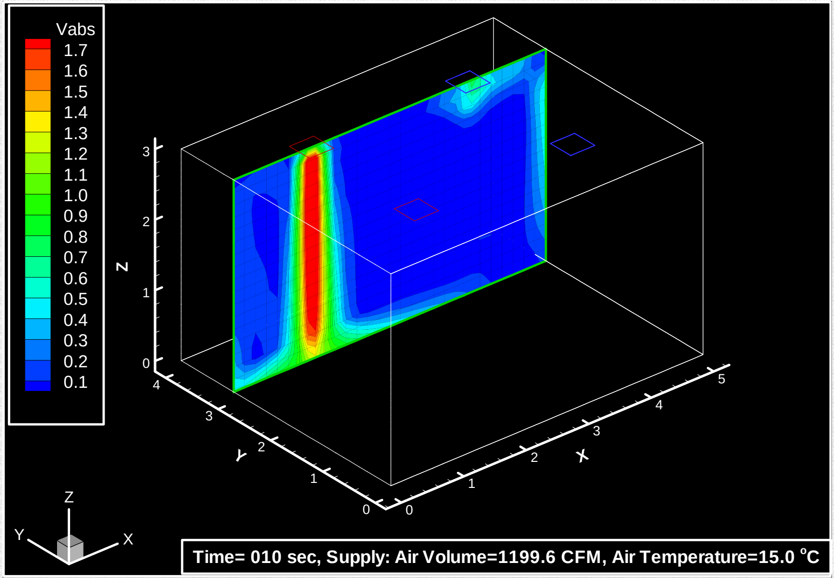
3-2 可變風量對室內氣流分佈之影響

- VAV可能造成之傾瀉現象（Dumping）



❑ 速度場





VAV	Low ΔT VAV

3-2.2 VAV改裝效益

❑ VAV FCU改善評估

飯店一般使用冷氣時間以18小時計，用CAV控制者主機運轉時間以18小時計，採用CAV溫度開關配合電動水泵控制者主機運轉時間以12小時計;

(a)冰水機 80 kW (b)冰水泵 7.5 kW

(c)冷卻水泵 7.5 kW (d)冷卻風扇 2.2 kW

(e)室內送風機 100W*50台 = 5 kW

室內送風機之消耗電量： 5 kW * 18 hr * 30 天 ＝ 2,700 kW・hr

空調主機之消耗電量：

（80kW + 7.5kW + 7.5kW + 2.2kW） * 12 hr * 30天＝ 34,992 kW・hr

每月空調總消耗電量： 34,992 + 2,700 ＝ 37,692 kW・hr

每月空調費用： 159 * 100 + 37,692 * 1.56 ＝ **74,699元**

傳統三速控溫器一個大約2000元但必需加裝電動水泵控制方能有效，電動水泵一只大約1200元。

溫控總價： 開關費用 ＋ 安裝費用

＝（ 2,000 + 1,200 ）* 50 ＋ 50 * 1,000

＝ **210,000 元**

3-2.2 VAV改裝效益

該飯店若改用VAV室內送風機，設主機運轉時間等於12小時*0.84=10小時。飯店裝置契約容量為100kW。（於外氣條件大約相同狀況下運轉比較，同樣由早上9:30開始運轉至24:00共消耗電力20.3kW-hr，同一條件VAV室內送風機系統共消耗電力I7.2kW-hr。節省電力達I6%）

室內送風機之消耗電量：5 kW * 18 hr * 30 天 * (100 – 76)% ＝ 648 kW hr

空調主機之消耗電量：

（80kW + 7.5kW + 7.5kW + 2.2kW)*12hr*30天*(100-16)%＝ 29,393 kW hr

每月空調總消耗電量： 29,393 + 648 ＝ 30,041 kW hr

每月空調費用： 159 * 100 + 30,041 * 1.56 ＝ **62,764元**

VAV室內送風機加裝TCSU控制器增加成本3000元計

溫控總價： 開關費用 ＋ 安裝費用

＝ 3,000 * 50 ＋ 50 * 1,000

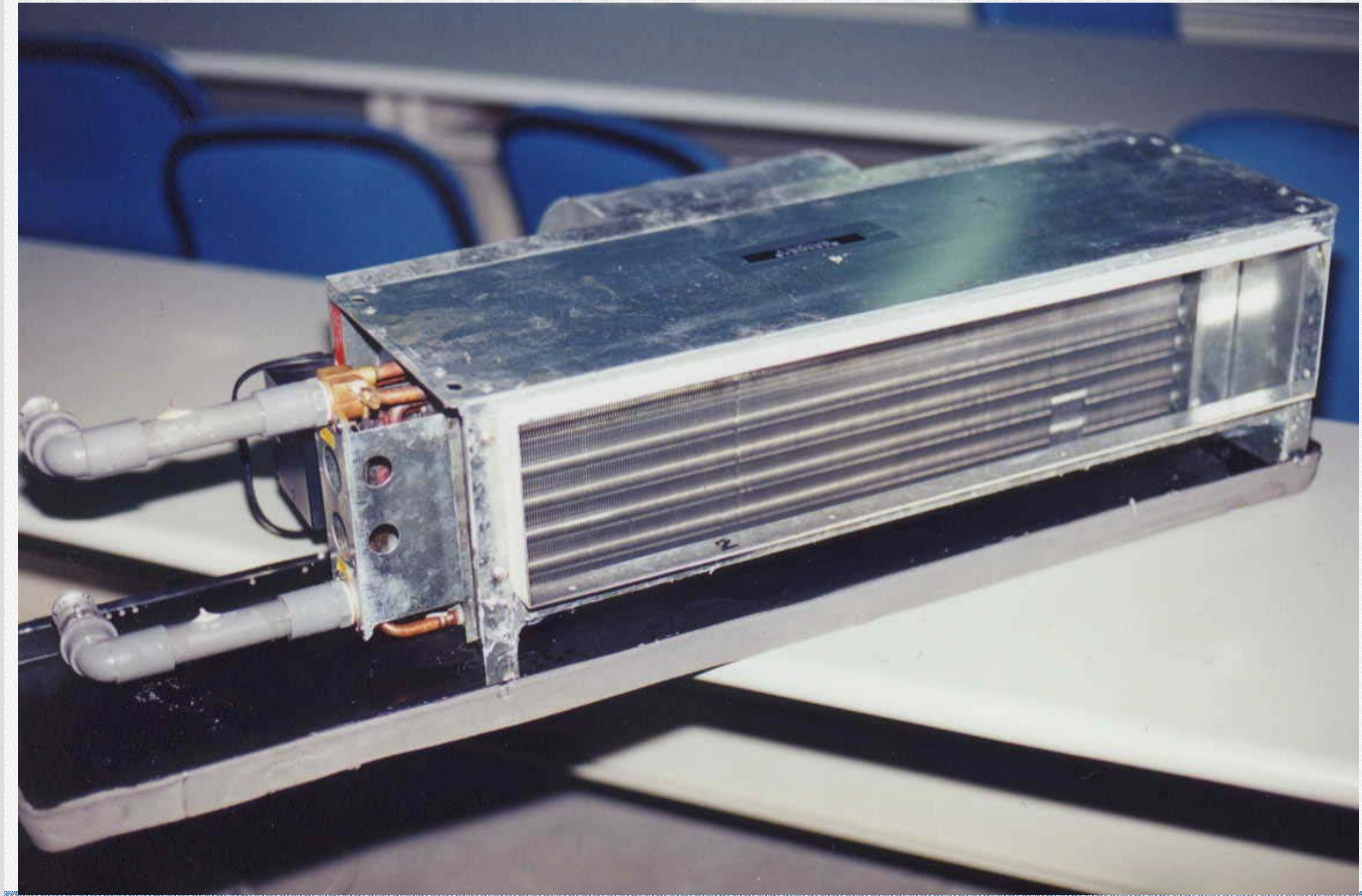
＝ **200,000 元**

3-3 室內空氣品質與空調節能

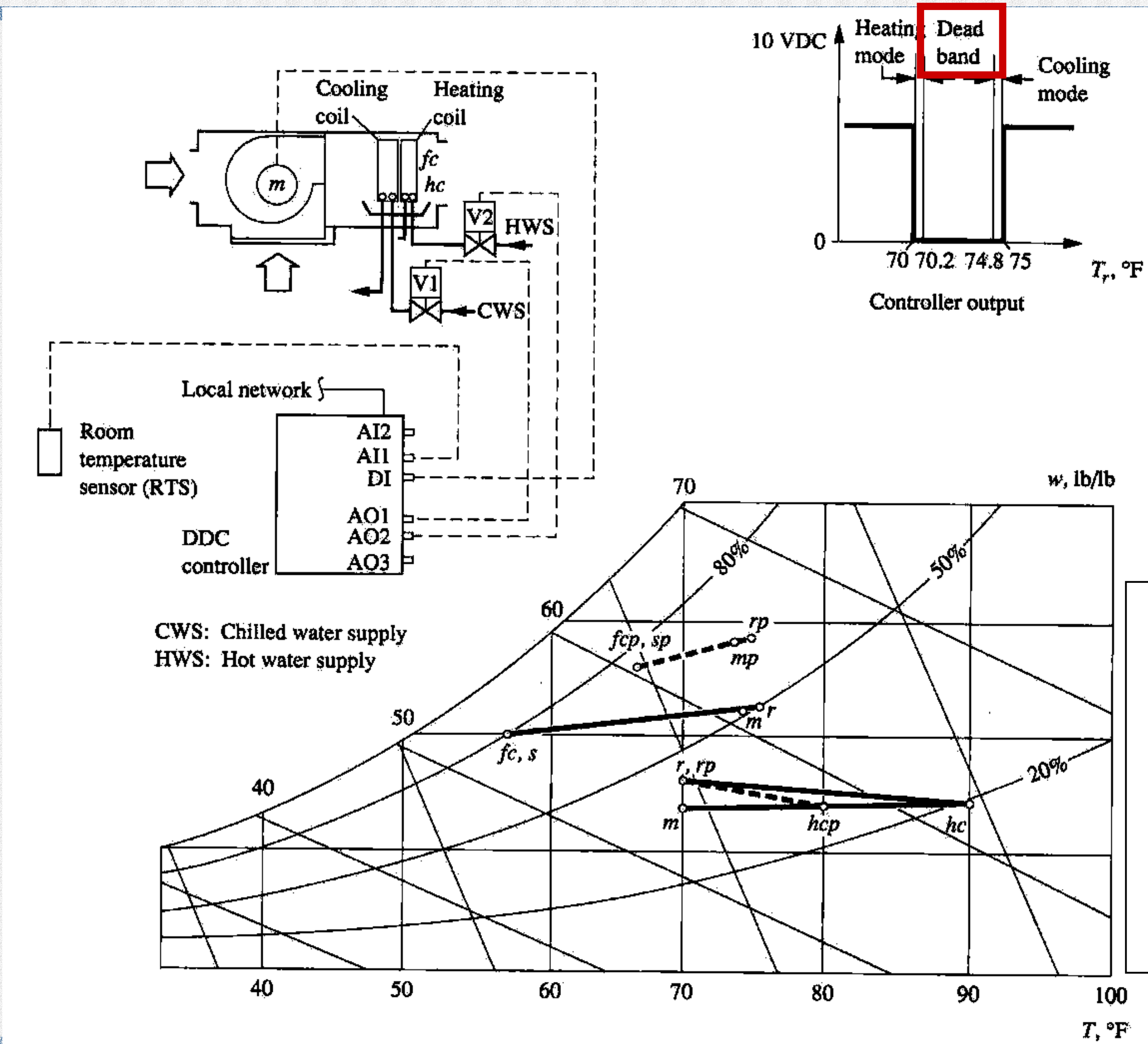
- ASHRAE 62 VS. 90.1
- Thermal Comfort, Health VS. Energy Saving
  - ✓ TB, SARS or …..
- Solutions:
  - ✓ Advanced technology.
    - Effective filter for TB, SARS …
  - ✓ Heat recovery.
  - ✓ System design with careful consideration.

四、高效率空調設備之應用

4-1 VAV Fan-Coil Units



4-1 Variable Air Volume (VAV)



資料來源： Shan K. Wang. 2001. Handbook of *Air-Conditioning and Refrigeration*, McGraw-Hill Professional.

4-1 Variable Air Volume (VAV)

2. VAV Box

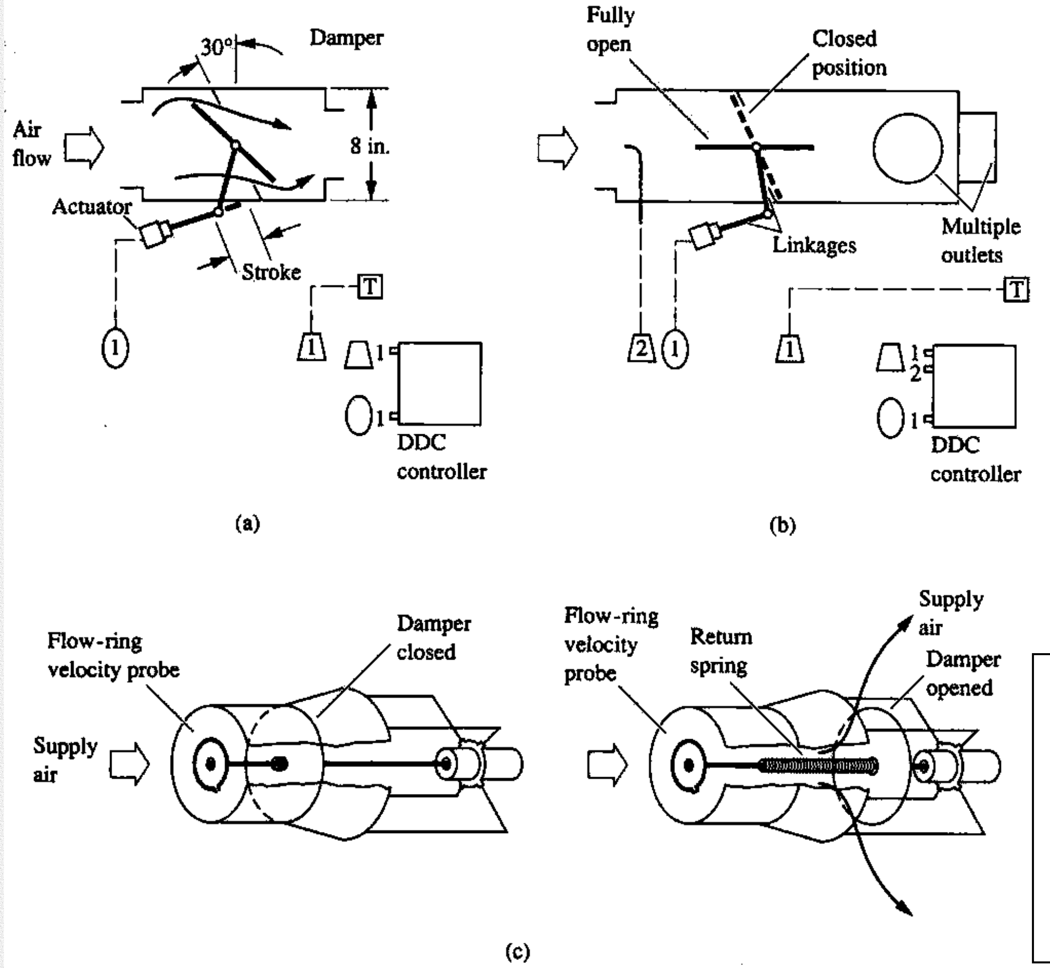
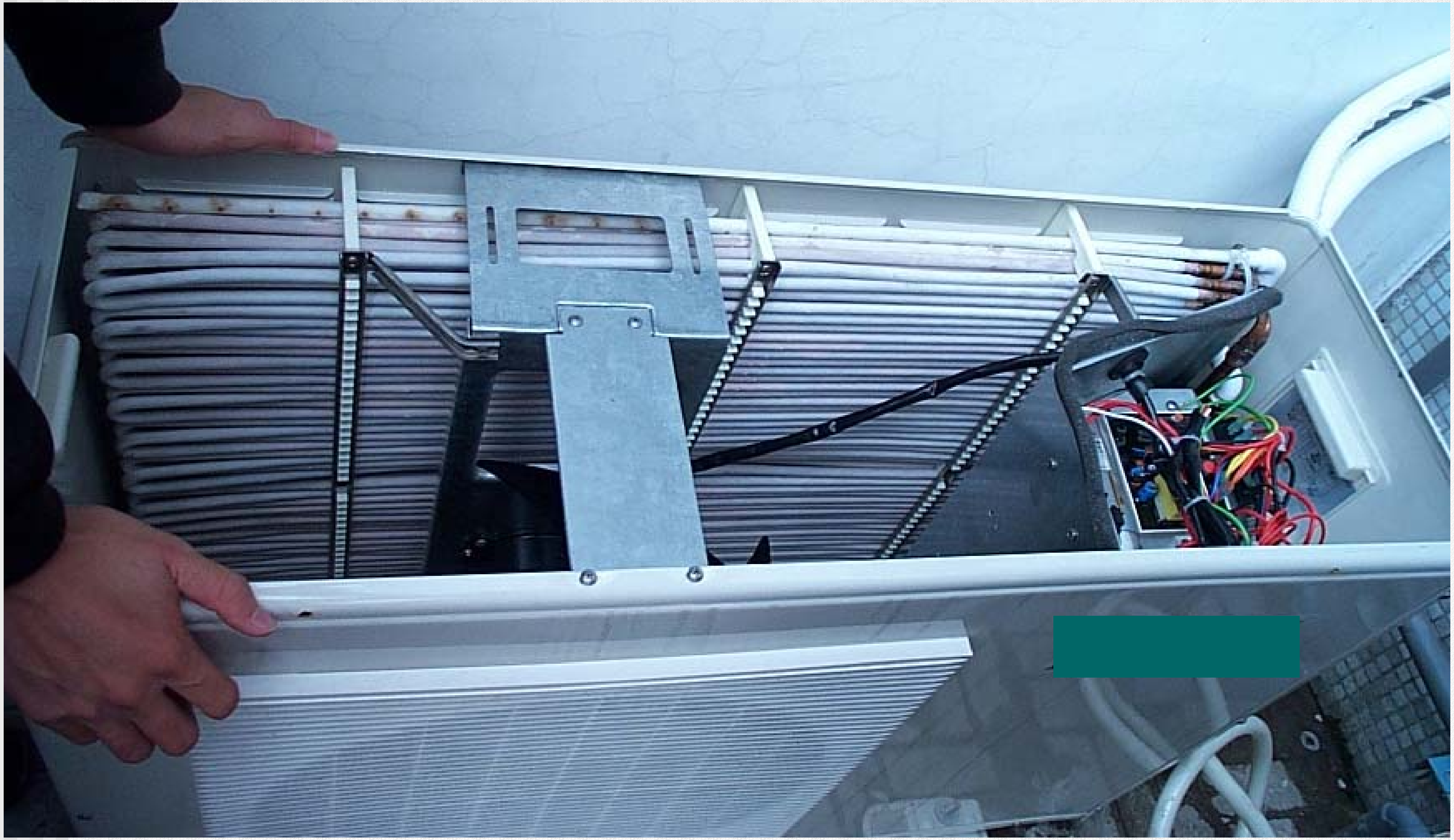


FIGURE 27.3 VAV boxes: (a) single-blade, pressure-dependent; (b) single-blade, pressure-independent; and (c) air valve.

資料來源： Shan K. Wang. 2001. Handbook of *Air-Conditioning and Refrigeration*, McGraw-Hill Professional.

4-2 Evaporative Cooling

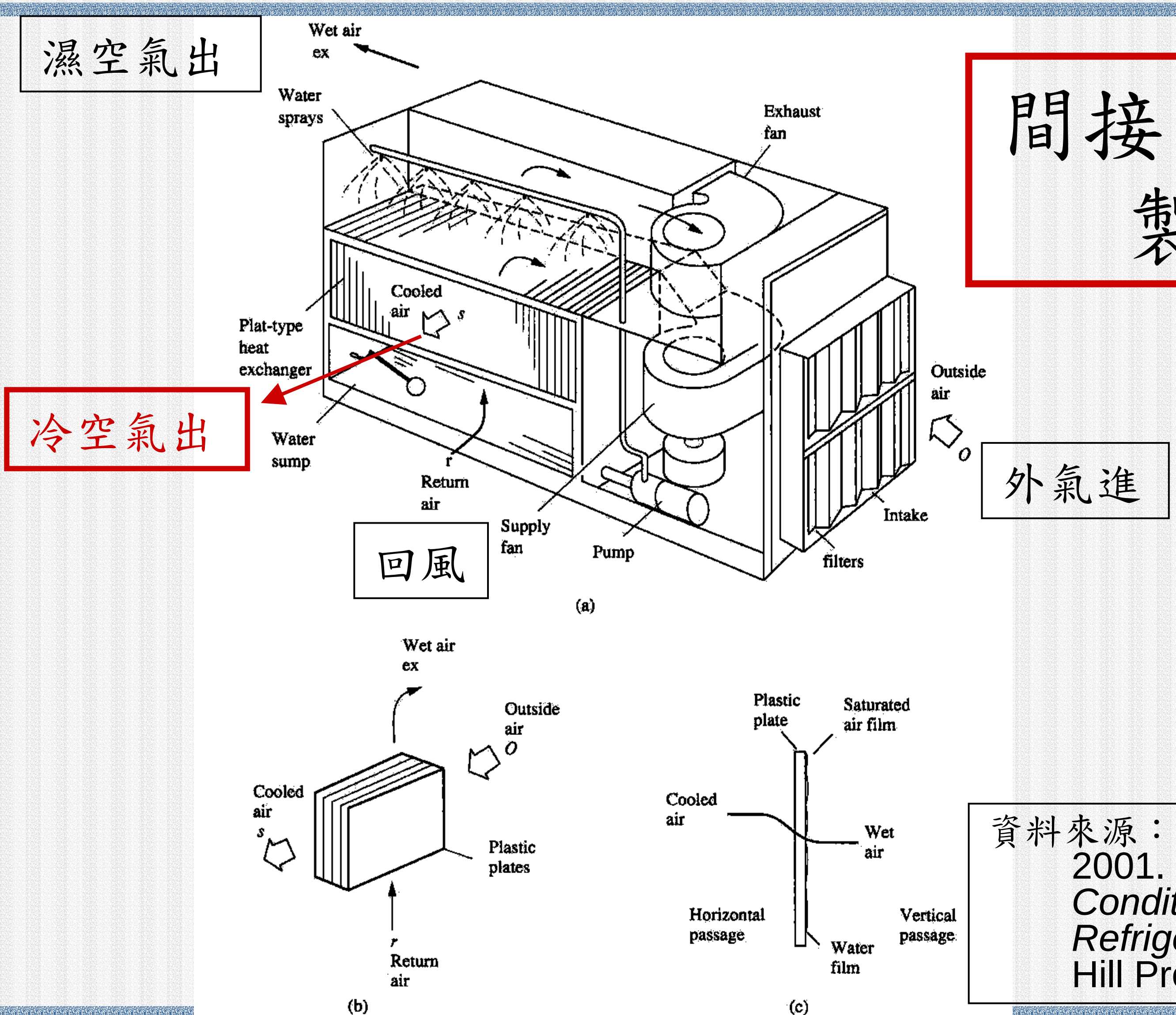


4-2 Evaporative Cooling

- 冷氣機之能源效率比值(EER)標準表

空調機種類			91.01.01 法規標準(EER) kcal/h・W	冷氣機節能標章 能源效率標準
單體式 (窗型冷氣機)	冷氣能力小於 2000kcal/h		2.33	2.68 以上
	冷氣能力 2000kcal/h 以上 冷氣能力 3550kcal/h 以下		2.38	2.74 以上
	冷氣能力大於 3550kcal/h		2.24	2.58 以上
分離式	冷氣能力 3550kcal/h 以下	一般式	2.55	2.93 以上
		變頻式	2.38	2.74 以上
	冷氣能力大於 3550kcal/h		2.35	2.70 以上

4-2 Evaporative Cooling



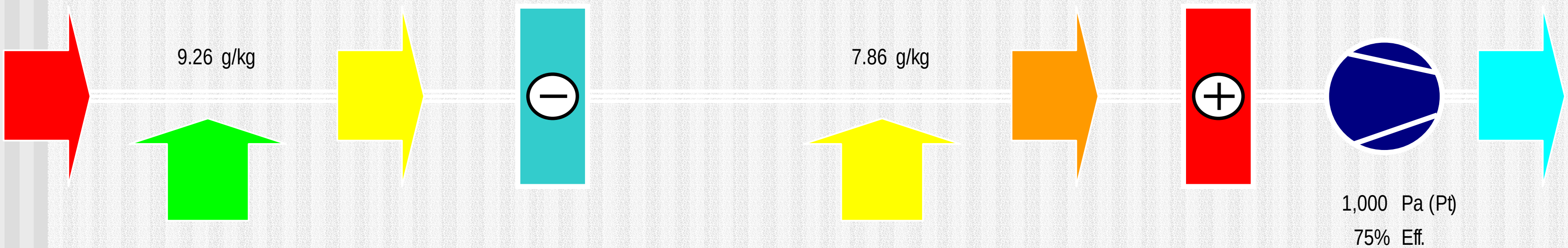
間接蒸發式製冷

資料來源： Shan K. Wang. 2001. Handbook of *Air-Conditioning and Refrigeration*, McGraw-Hill Professional.

4-3 熱管之應用

1. 電子廠外氣空調箱(MAU)

OA Folw Rate	RA Folw Rate	MA Folw Rate	Total Heat	LA Folw Rate	BA Folw Rate	LA' Folw Rate	Total Heat	Fan Folw Rate	SA Folw Rate
10,000 CMH	92,828 CMH	102,820 CMH	585.5 kW	97,736 CMH	0 CMH	97,736 CMH	-182.4 kW	99,620 CMH	100,000 CMH
2.78 m^3/s	25.79 m^3/s	28.56 m^3/s	Sensible Heat	27.15 m^3/s	0.00 m^3/s	27.15 m^3/s	Sensible Heat	27.67 m^3/s	27.78 m^3/s
3.07 kg/s	30.35 kg/s	33.42 kg/s	456.9 kW	33.37 kg/s	0.00 kg/s	33.37 kg/s	-182.4 kW	33.37 kg/s	33.37 kg/s
OA Intake			Cooling Coil				Heater	Recirculation Fan	

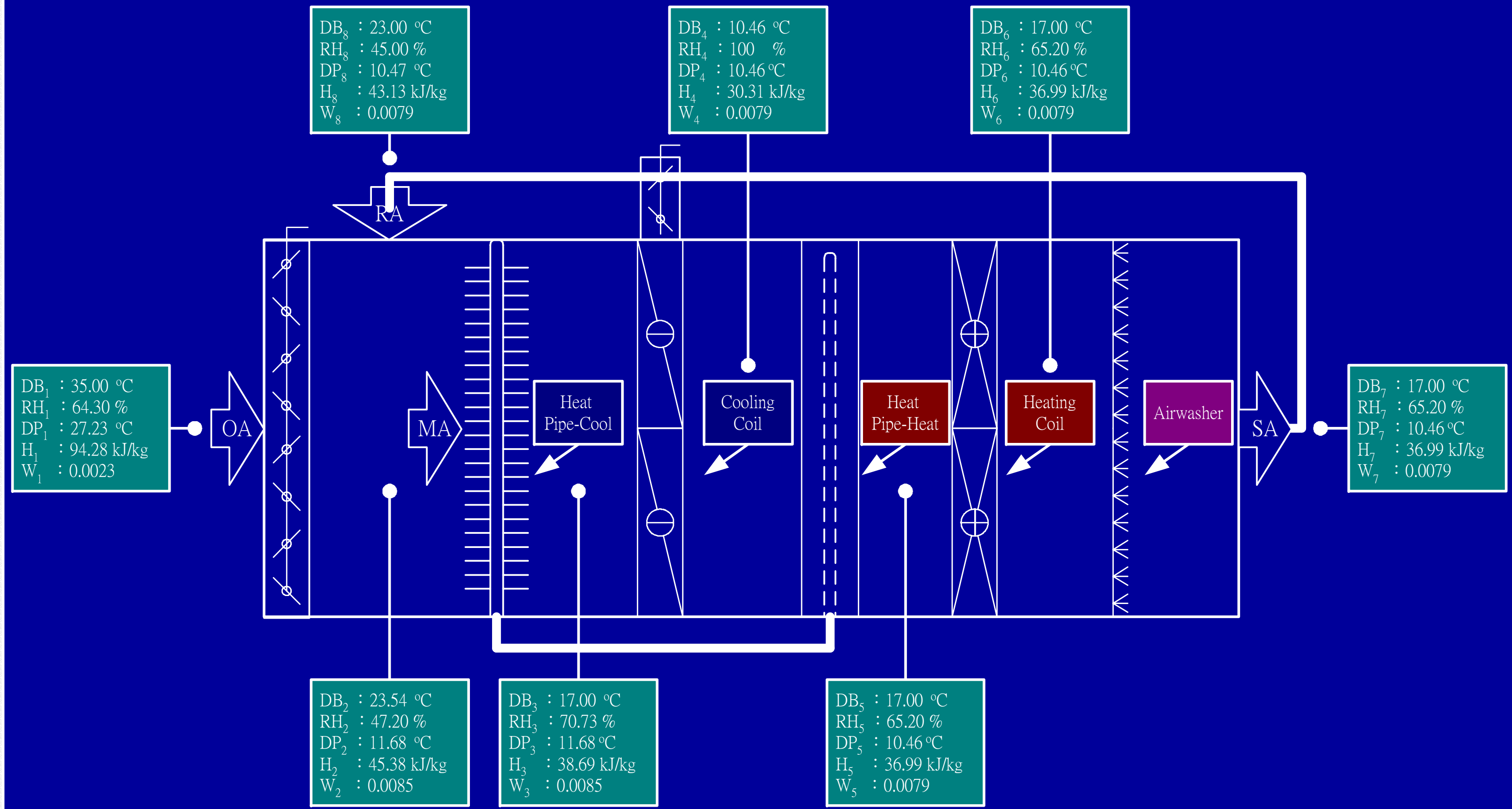


OA Condition	RA Condition	MA Condition	CHS Temp.	LA Condition	BA Condition	LA' Condition	Heater	LA" Condition	SA Condition
35.00 DB°C	23.00 DB°C	24.10 DB°C	6.0 °C	10.43 DB°C	24.10 DB°C	10.43 DB°C	182.4 kW	15.89 DB°C	17.00 DB°C
29.00 WB°C	15.47 WB°C	17.07 WB°C	CHR Temp.	10.43 WB°C	17.07 WB°C	10.43 WB°C		12.73 WB°C	13.17 WB°C
64.3 RH%	45.0 RH%	49.5 RH%	12.0 °C	100.0 RH%	49.5 RH%	100.0 RH%		70.0 RH%	65.2 RH%
23.03 g/kg	7.86 g/kg	9.26 g/kg	CHW Flow Rate	7.86 g/kg	9.26 g/kg	7.86 g/kg		7.86 g/kg	7.86 g/kg
94.3 kJ/kg	43.1 kJ/kg	47.8 kJ/kg	23.31 L/s	30.3 kJ/kg	47.8 kJ/kg	30.3 kJ/kg		35.9 kJ/kg	37.0 kJ/kg
1.105 kg/m^3	1.177 kg/m^3	1.170 kg/m^3	Condensate	1.229 kg/m^3	1.170 kg/m^3	1.229 kg/m^3	Cooling Capacity	1.206 kg/m^3	1.201 kg/m^3
27.20 DP°C	10.44 DP°C	12.88 DP°C	168.9 L/hr	10.43 DP°C	12.88 DP°C	10.43 DP°C	200.2 kW	10.44 DP°C	10.43 DP°C

Power Consumption Summary

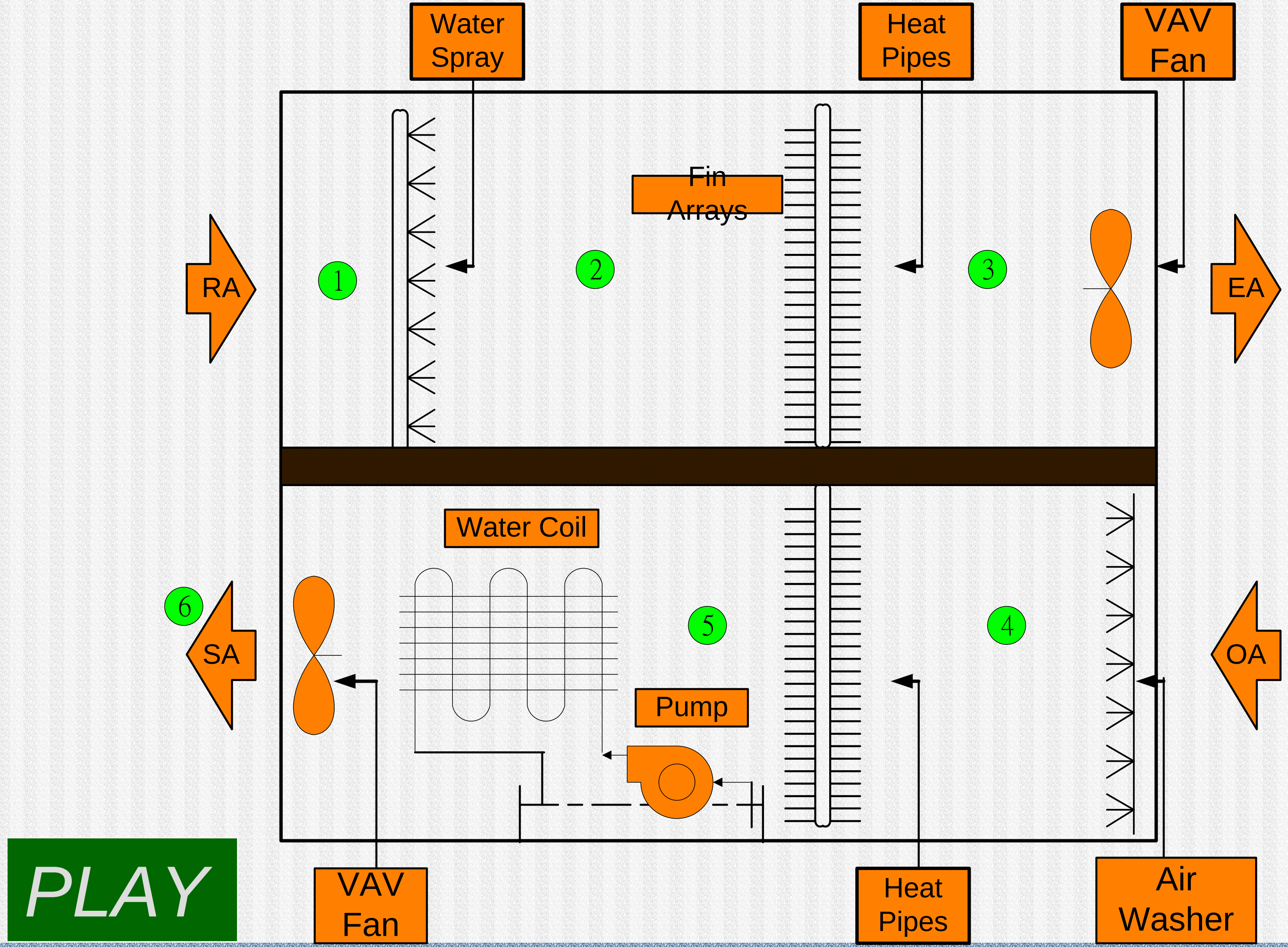
Item		q_1				q_4	Recirculation Fan	Summary
Load		585.5 kW				182.4 kW	36.9 kW	
COP		3.50				1.00	1.00	
Power Consumption		167.3 kW				182.4 kW	36.9 kW	386.5 kW

4-3 熱管之應用



Item	Heat Pipe	Cooling Coil	Heating Coil
Load (kW)	226.69	365.20	0.00
COP		3.50	1.00
Power Consumption (kW)		104.34	0.00

4-4 自然空調機


Water Spray
Heat Pipes
VAV Fan
Fin Arrays
RA
1
2
3
EA
Water Coil
6
SA
5
4
OA
Pump
PLAY
VAV Fan
Heat Pipes
Air Washer

4-5 Variable Refrigerant Volume (VRV) System

- VRV空調系統採用變頻式壓縮機，控制壓縮機馬達的轉速，當室內環境溫度改變時，控制系統會視負荷大小輸出不同的頻率。
- 當冷氣運轉達到設定溫度時，壓縮機會改以低頻率運轉，使室內溫度維持恆溫狀態，可節省電力。
  - ✓ VRV空調系統控制頻率的變動範圍約在30Hz~116Hz之間。
- VRV系統的冷媒控制器採用電子式膨脹閥，其藉由兩組溫度感知器，置於蒸發器的出入口位置，將感知器的信號經計算後傳輸至膨脹閥，指示其旋轉並打開閥體開度。閥體開度可隨感知器獲得的信號調整，因此可精確控制冷媒流量。

4-5 Variable Refrigerant Volume (VRV) System

耗電實績分析

(新加坡電力公司)

大樓名稱	總電力 kW/m²	空調電力 kW/m²	超出 %	空調類別
Apollo Centre	17.6	12.1	36 %	冰水機
Odeon Tower	19.4	12.0	34 %	冰水機
A.I.A. Robinsons	26.6	13.2	48 %	冰水機
A.I.A. Alexandra	24.2	8.9	基點	VRV

4-6 Variable Refrigerant Flow (VRF) System

廠　家	產　品	備　　註
Mitsubishi	City Multi VRF	R22/R407C, 多種形式, 冷暖氣/熱回收
		1對32, 最大能力：冷氣87.3 kW, 暖氣97.7 kW
		（**PUHY-P750**型號）
Toshiba	Super Multi Intelligence (SMi)	R407C, 3-Pipe system, 熱回收冷暖氣,
		1對16, 最大能力：冷氣28 kW, 暖氣31.5 kW
	Modular Multi System (MMS)	R407C, 室外機為變速/定速組合
		1對40, 冷氣能力 22.4 kW to 128.8 kW
Fujitsu	Airstage VRF	R407C, 室外機為三壓縮機"動力累積技術",
		熱回收冷暖氣,
		1對16, 能力 2.15 kW to 17 kW
Hitachi	Set-Free VRF	R407C, 2-Pipe或3-Pipe system, 熱回收冷暖氣,
		最大能力：90 kW
Carrier	Multi VRF	R407C, 冷暖氣, 室外機為變頻
		1對16, 最大能力：冷氣能力 25 kW, 暖氣28 kW

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-END-

敬請指教