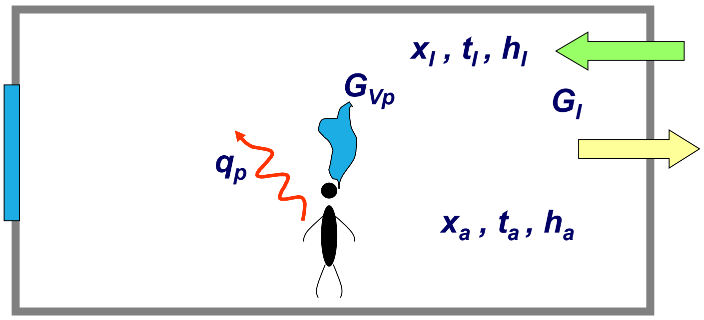
FULL AIR SYSTEMS

FULL AIR SYSTEMS

PROS	CONS
Good possibility to control indoor conditions	Poor energy efficiency
Complete absence of pipng etc.	Size of air ducts
Localization in a unique Air Handling Unit (AHU) the main components of the plant	Need of accurate balancing of air ducts
Easy installation of heat recovery units	

BALANCEOF A ROOM



THERMAL AND VAPOUR BALANCE OF A ROOM

$$q_p = G_I \; c_P \; (t_a - t_I) \qquad (1)$$

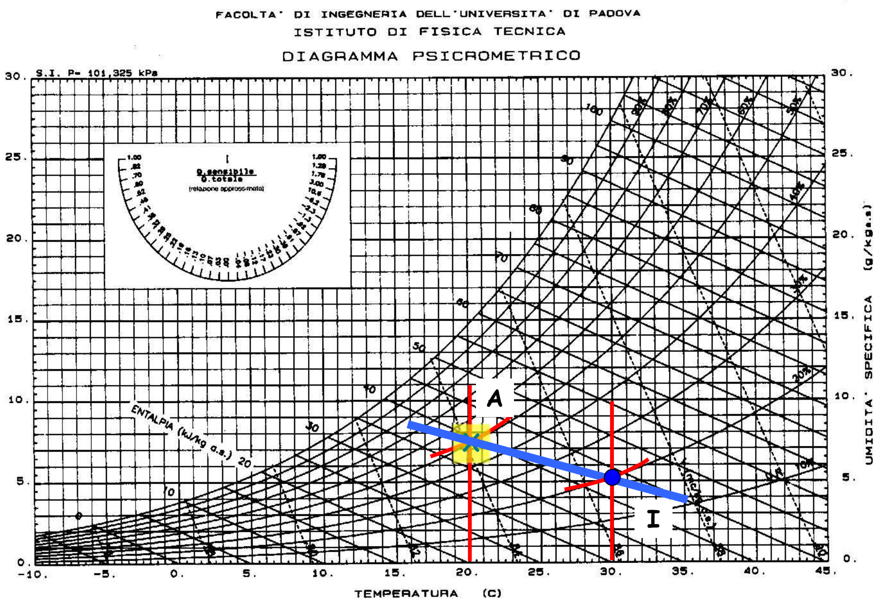
$$G_{vp} = G_I \, (x_a - x_I) \qquad (2)$$

$$q_p + r \, G_{vp} = G_I \, (h_a - h_I) \qquad (3)$$

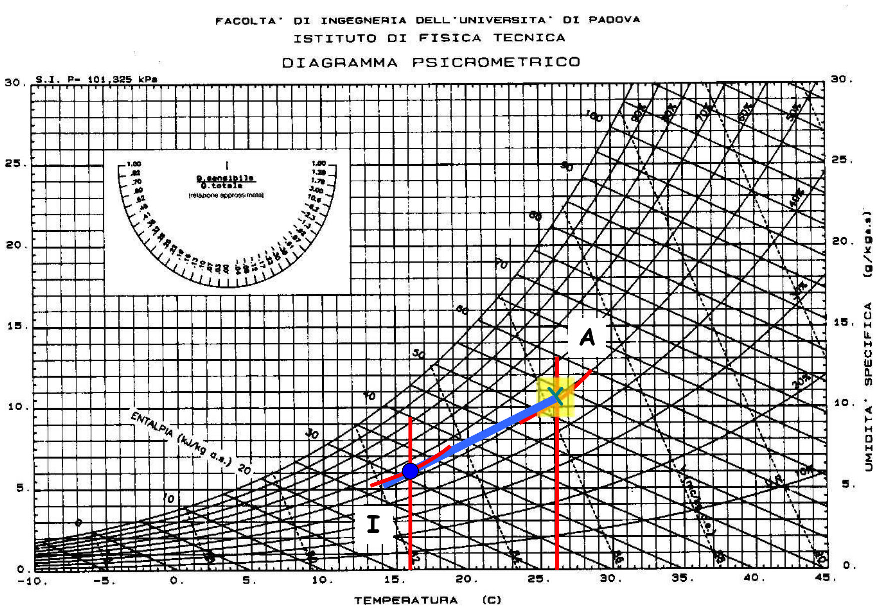
$$\frac{3}{2} \longrightarrow \frac{q_{tp}}{G_{vp}} = \frac{h_a - h_I}{x_a - x_I}$$

$$\frac{1}{3} \longrightarrow = \frac{q_p}{q_{pt}} = \frac{c_P \; (t_a - t_I)}{h_a - h_I}$$

WINTER



SUMMER



The greater the distance from I and A the lower the air flow rate

LOW CAP-EX

Lower flow rate $\longrightarrow$ ***IAQ ?***

$t_I - t_a = 15 \div 25\ °C$ in *HEATING*

$t_a - t_I = 10 \div 12\ °C$ in *COOLING*

IN THESE PLANTS:

- ✓ if $G_{a,fresh} < G_I$ $\longrightarrow$ $G_{recirculation} = G_I - G_{a,fresh}$
- ✓ se $G_{a,fresh} > G_I$ $\longrightarrow$ Just fresh air $G_I = G_{a,fresh}$

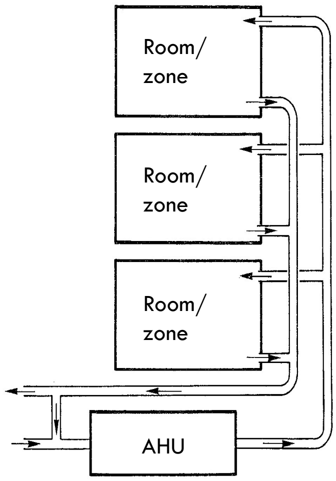
In a plant the design conditions occur rarely

Conditions change over the time

Different zones my require different loads

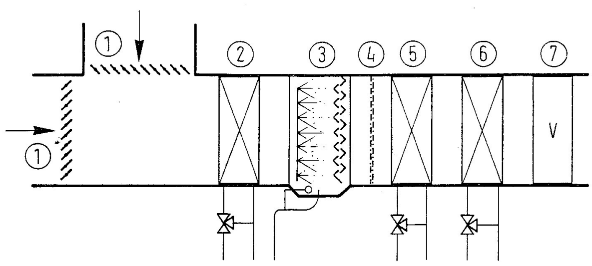
(living room/bedrooms, South-North, West-East, etc.)

SINGLE DUCT



- *A single duct connects the AHU to the rooms/zones*
- *The air flow rate may be different from zone to zone, but the inlet conditions are the same (temperature and relative humidity)*
- *Same straight line for each room/zone*
- *The set of the rooms supplied by a single duct represent the same climatic zone*

SCHEME OF AN AHU



1. *Equalizing dampers*
2. Pre-heating coil
3. Atomizing humidifier
4. Droplet separator
5. Cooling coil
6. Reheat coil
7. Fan

AHU:

<u>*HEATING OPERATION*</u>

The pre-heat coil determines the inlet humidity ratio in the room.

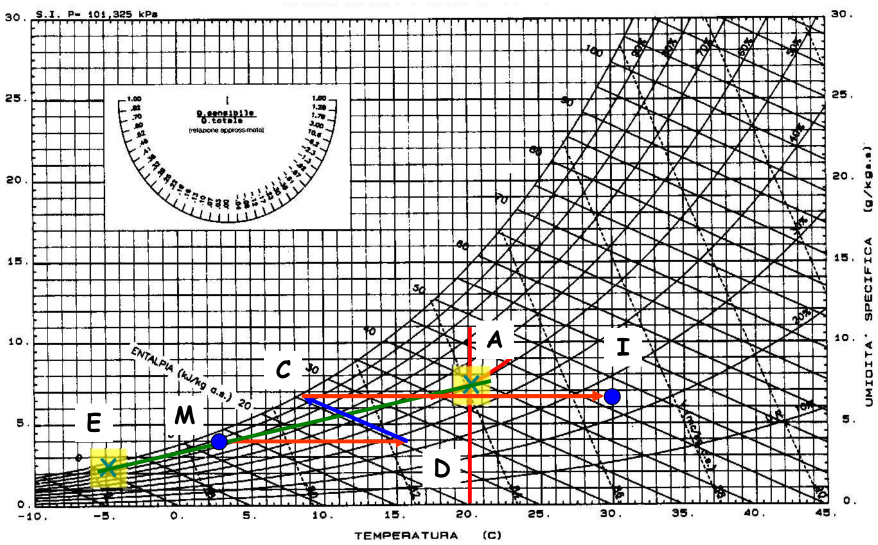
The reheat coil has the goal to control t_{IMM}

<u>*COOLING OPERATION*</u>

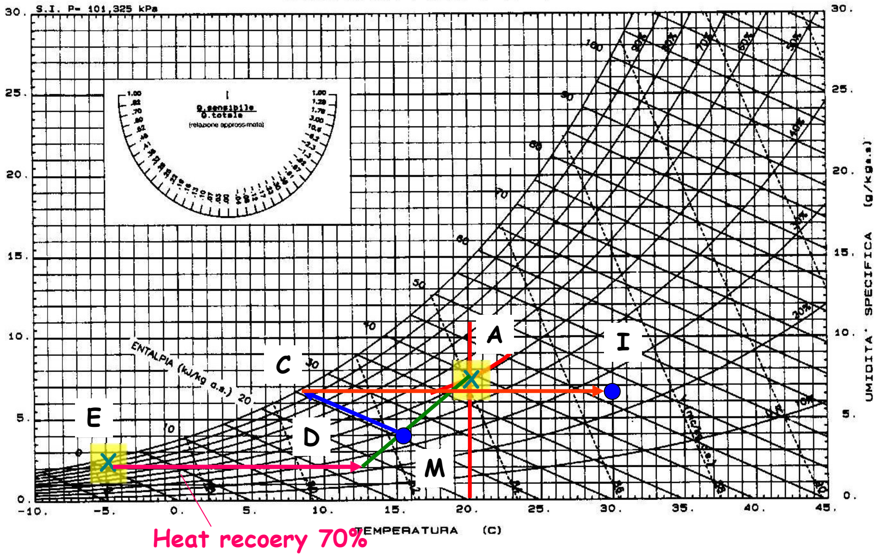
The cooling coil varies the inlet humidity ratio.

The reheat coil controls the inlet temperature

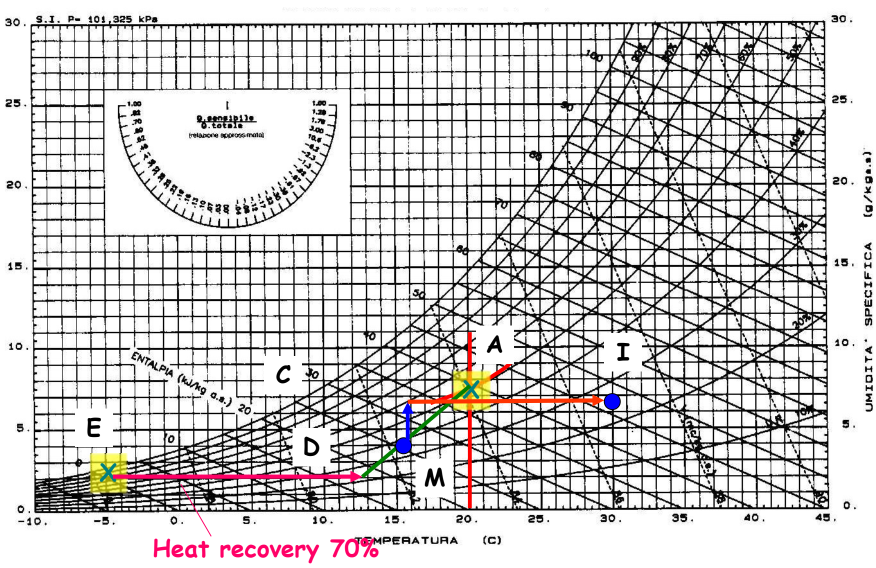
Winter no heat recovery, atominzing humidifier



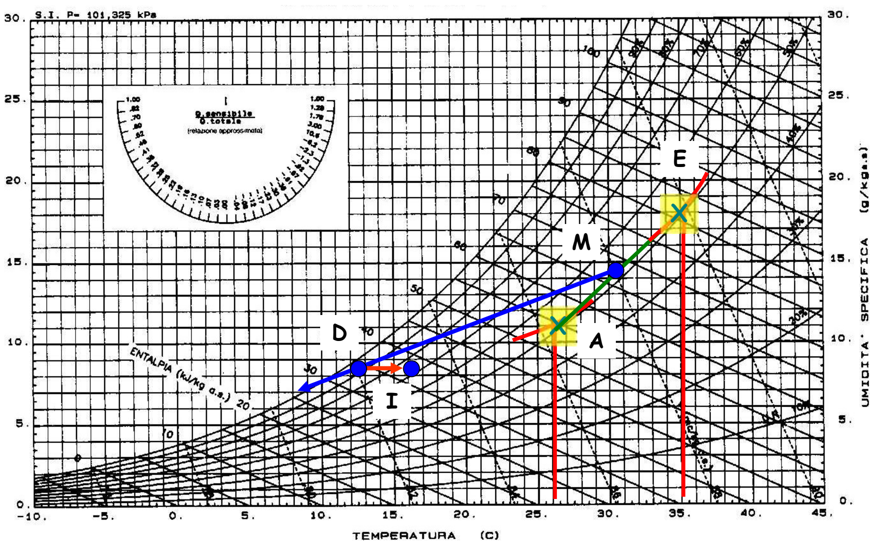
Winter with heat recovery (70%), atominzing humidifier



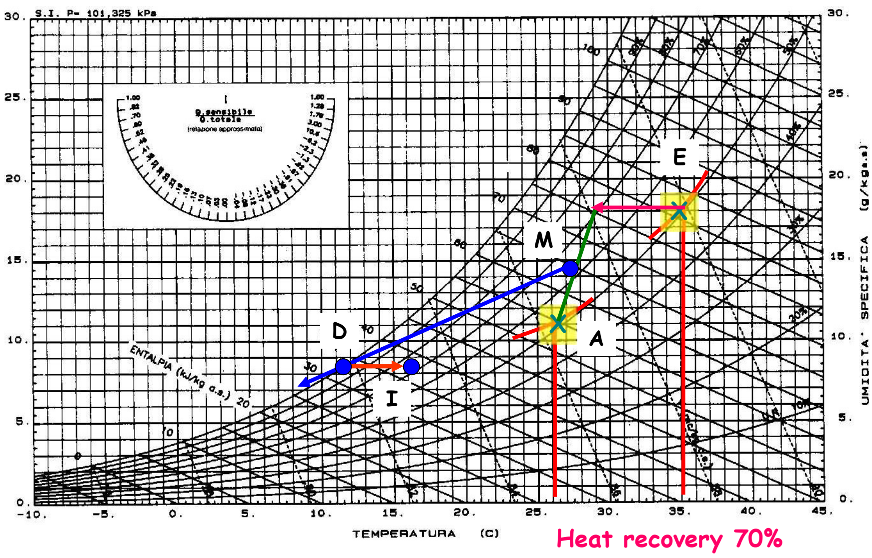
Winter with heat recovery (70%), steam humidifier



Summer no heat recovery



Summer with heat recovery



- *Adaptable* and *Precise* in controlling temperature and humidity
- ***With different zones*** ⟶ ***each with a un SINGLE DUCT & AHU***

- ***Sizing*** { ***heating*** / ***cooling***

- ***Select the greater flow rate as design flow rate***

↳ ***If there is a difference between the 2 flow rates:***

  - ***maximum***
  - ***reduced (by means of a fan with variable flow rate)***

↳ ***In the seocond case (reduced flow rate) it is necessary to set again the inlet conditions (the inlet conditions change)***

HOW TO SIZE THE COILS:

Preheating coil:

$x_D = x_I$ (latent load = 0)

$G_I c_p (t_D - t_M)$ = heat supplied as preheating

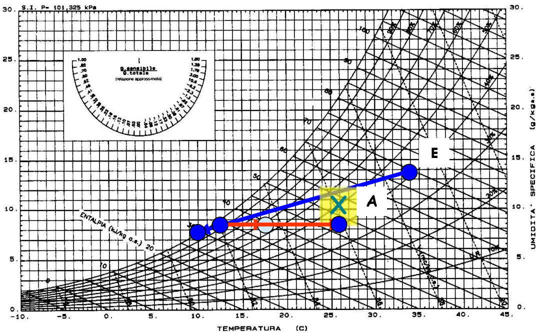
- *Reheat coil:*

For cooling: $t_I = t_A$ (sensible load = 0)

$G_I c_p (t_I - t_C)$ = heat supplied in winter

$G_I c_p (t_A - t_D)$ = heat supplied in summer

Whichever is greater



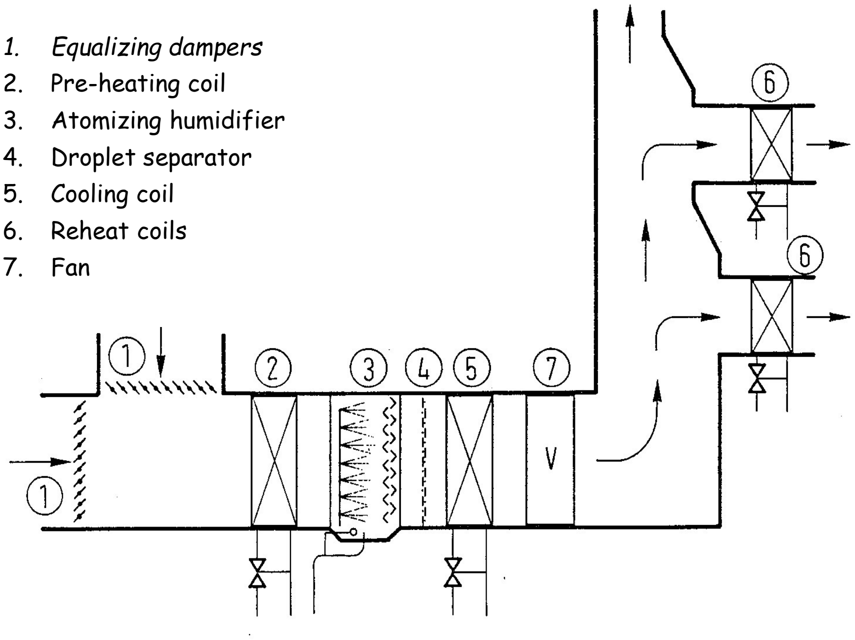
MULTIZONE SYSTEMS WITH REHEAT COILS

✓ *Zones with different loads*

✓ *There is just one **AHU** e and the reheat coils are in stalled locally*

✓ *The control can be either on the temperature or on the relative humidity (just one of them)*

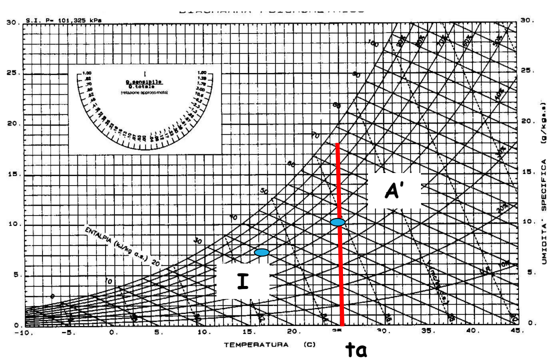
1. *Equalizing dampers*
2. Pre-heating coil
3. Atomizing humidifier
4. Droplet separator
5. Cooling coil
6. Reheat coils
7. Fan



Case with room temperature control:

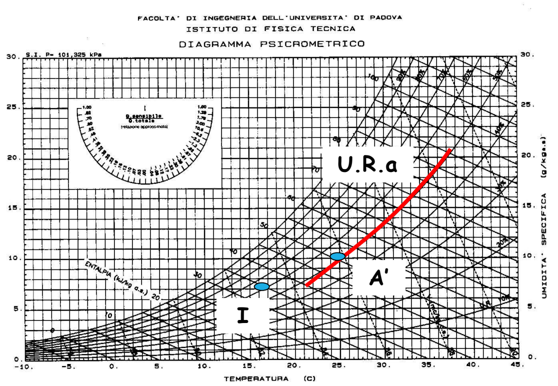
The control is based on a set-point temperature of the room t_a

The humidity ratio can change depending on the actual vapour balance. The humidity ratio can vary and hence the conditions A' can move on the red straight segment t_a varying the relative humidity.



- ## Case with relative humidity control:

The relative humidity is kept constant (on the RH = const. curve) but the temperature can change



• *Sizing the ventilation rate:*

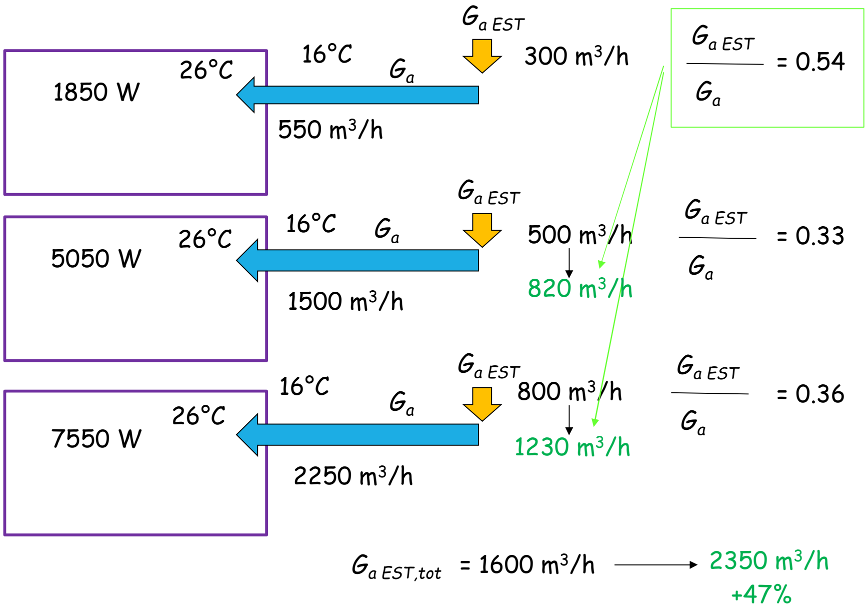
$$G_{a\,TOT} = \sum_j G_{aj}$$

$$\frac{G_{a\,FRESH}}{G_a}$$ Room by room

The maximum ratio M determines the sharing of fresh air

$$G_{a\,FRESH} = M\,G_a$$

Example:



VARIABLE AIR VOLUME

Equations 1 and 2 can be managed by changing the aor flow rate

$$q_p = G_I \; c_p \; (t_a - t_I) \quad (1)$$

$$G_{vp} = G_I \; (x_a - x_I) \quad (2)$$

Terminal units with variable geometry are activated by means of a servomotor actuated by a thermostat

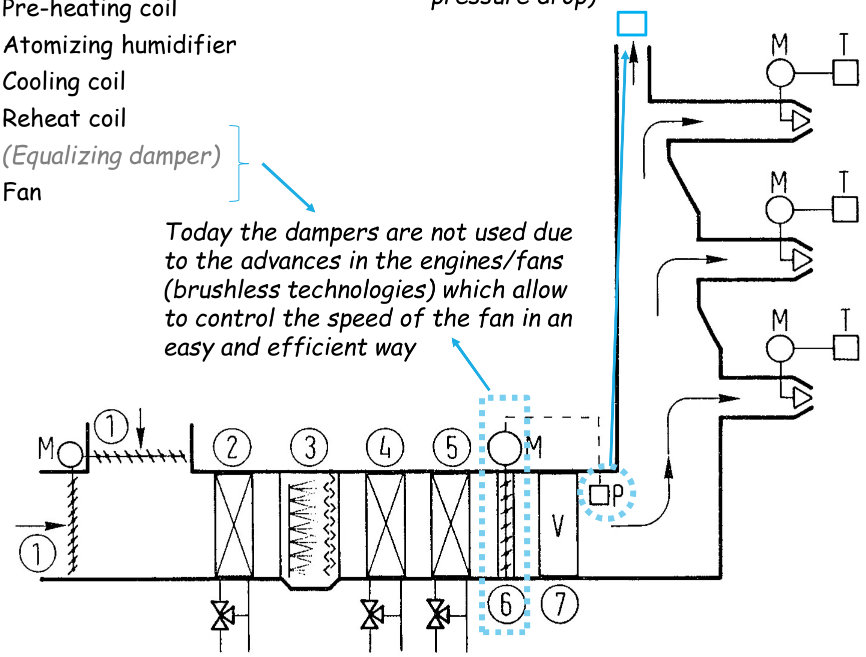
The air flows where it is required

Less air flowing in the ducts

1. *Equalizing dampers*
2. Pre-heating coil
3. Atomizing humidifier
4. Cooling coil
5. Reheat coil
6. *(Equalizing damper)*
7. Fan

Usually in the farthest point (largest pressure drop)

Today the dampers are not used due to the advances in the engines/fans (brushless technologies) which allow to control the speed of the fan in an easy and efficient way

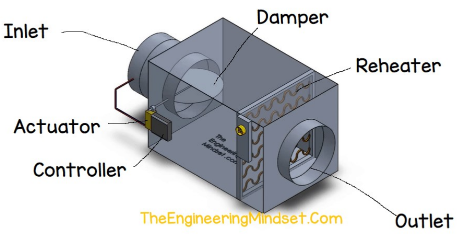


It is important to control the pressure in the main duct (hence on the fan speed) when the damper is activated in order to balance the whole duct system.

This way the variation of the air flow in a zone will not affect the flow rate in other zones.

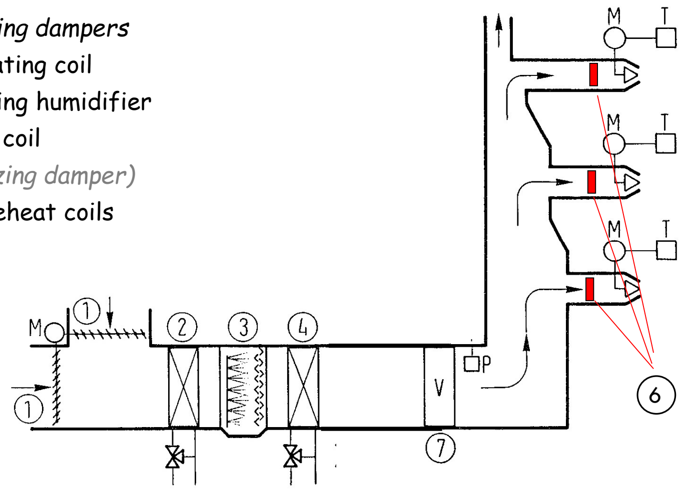
Hence it is requested that the whole system is an integrated solution.

The flow rate can be lowered down to 20-30% of nominal value. Lowering the rate can lead to a poor IAQ risk. For this purpose equalizing dampers are placed in the fresh air circuit and in the recirculation circuit



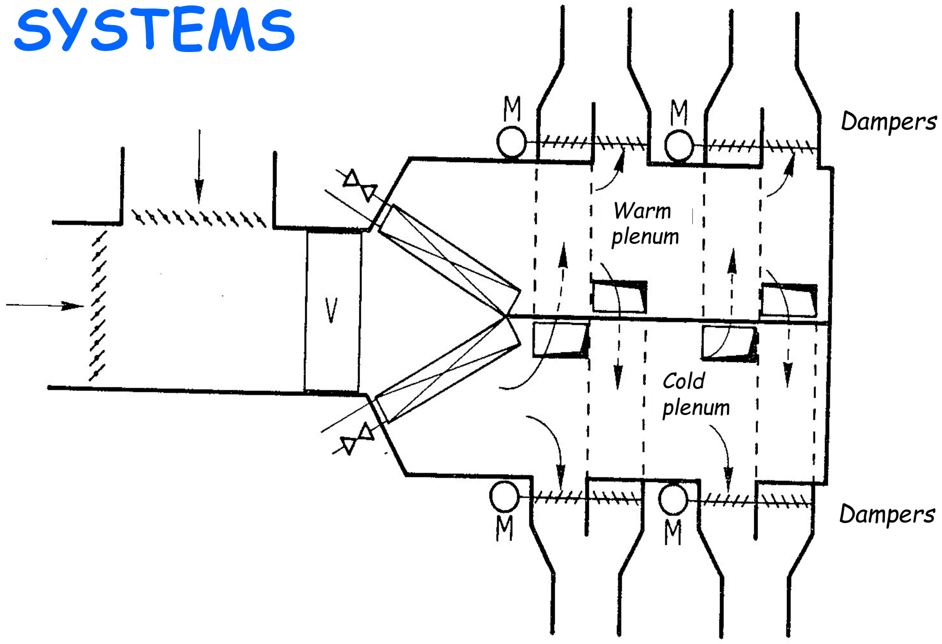
MULTIZONE SYSTEMS WITH REHEAT COILS AND VAV

1. *Equalizing dampers*
2. Pre-heating coil
3. Atomizing humidifier
4. Cooling coil
5. *(Equalizing damper)*
6. Local reheat coils
7. Fan

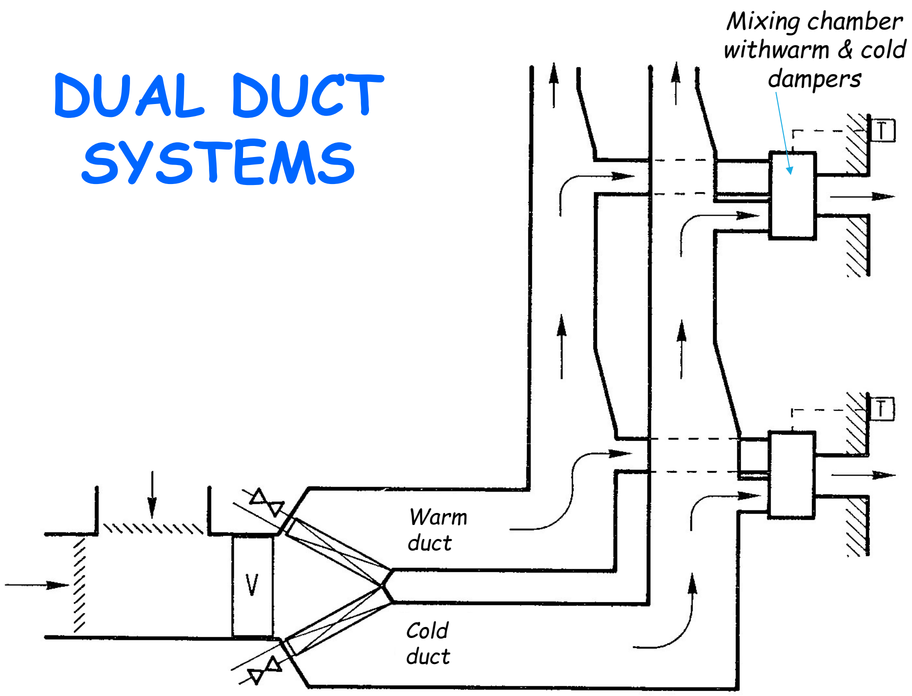


Control strategy: flow rate first and then reheat coil

DUAL PLENUM SYSTEMS



DUAL DUCT SYSTEMS



- Low installation costs

- In the **AHU** are available:
  - G_{COLD} → Cool plenum
  - G_{WARM} → Warm plenum

In each zone G_{Ij} = COST managing the equalizing dampers equalizing dampers which mix the warm and the cold air

- The inlet point ***I*** is easy to keep
- Small changes in X

Too low (winter)

Humidifier in the recirculation system

Resulting by the two mixing flow rates

t warm plenum:

- Summer → t_{ext}
- Winter → t_a + 20 ÷ 25 °C

t cold plenum:

CONSTANT = 12 ÷ 15 °C → In winter the cooling coil does not work and the air flow rate varies

G_{EST} → IAQ

In cold climates to avoid too low temperaures → Preheating coils before the fan or heat recovery unit

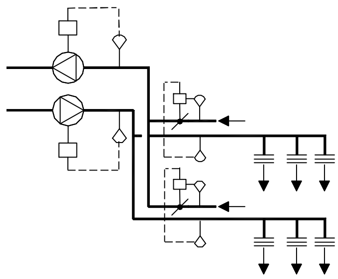
Variable Air Ventilation (VAV) & Demand ControlcVentilation (DCV)

DCV is a particular type of VAV

It is a VAV with automatic control on demand → DCV

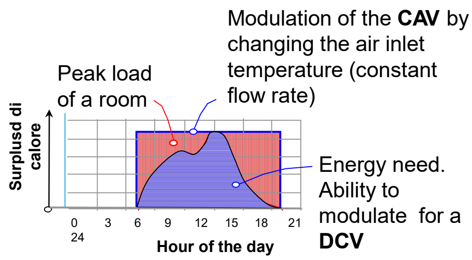
VAV
Ventilation with variable flow rate
VAV with automatic control depending on the demand → DCV

Different parameters can be set dealing with thermal comfort and/or IAQ



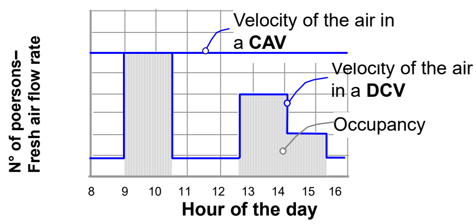
DCV SYSTEM VS. CAV SYSTEM

- **DCV for the comfort control** (heaqting/cooling load)



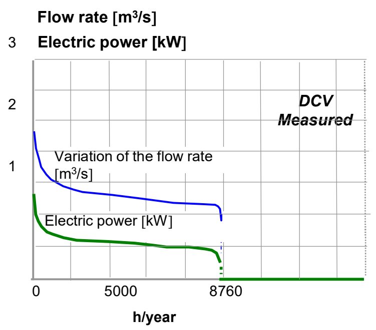
- **DCV for the IAQ control** (pollutant removal)

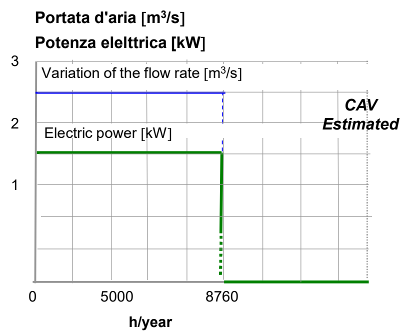
  A proper marker is the CO_2



Advantages of a DCV

Possibility to modulate the flow rate of the air all year round(ì (less electric energy for the auxiliaries)





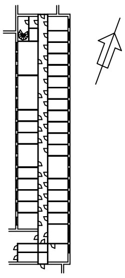
APPLICATIONS OF A DCV

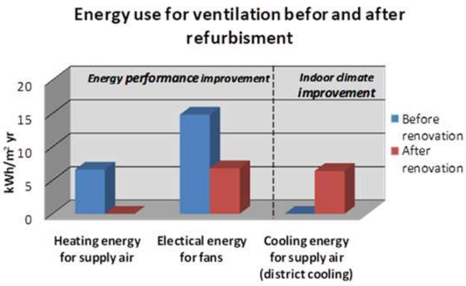
- For buildings with variable loads
  - ✓ Conference centres/auditorium;
  - ✓ Offices;
  - ✓ Restaurants;
  - ✓ Theatres;
  - ✓ Schools
  - ✓ …

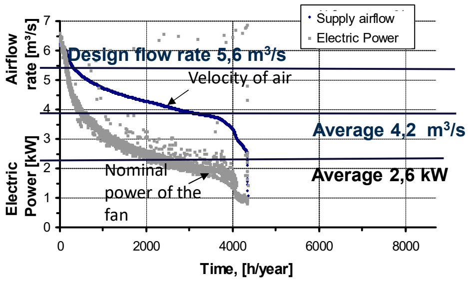
- The greater the variation of the loads, the larger the energy saving

EXAMPLE OF DCV

Retrofit of an office building
(CAV → DCV)
3500 m^2 with 107 offices







EXAMPLE OF DCV

Retrofit of an office building
(Administrative offices of a University)
2500 m^2 with 76 offices