Cooling generation systems
and
Insights on efficient production systems

Generation systems 1/2

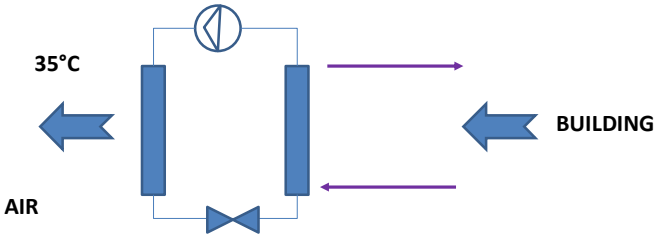
- Heating:
  - Boilers:
    - Fossil Fuels
    - Biomass boilers
  - Heat pumps (source/sink media):
    - Air-to-water
    - Water-to-water
    - Air-to-air
    - Water-to-air

Generation systems 2/2

- Cooling:
  - Compression Chillers:
    - Hydronic system
      - Condensation in ari
      - Condensation in water
    - Direct expansion
      - Split systems/VRV
      - Rooftop
  - Absorption chillers:

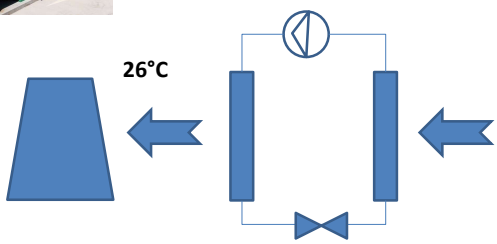
3

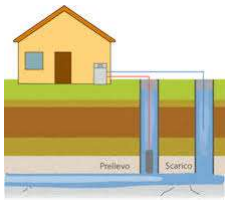
AIR TO WATER CHILLER



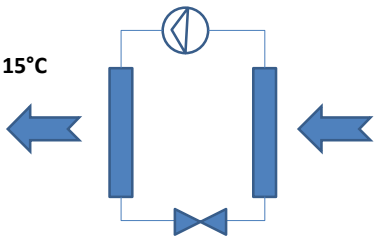
WATER TO WATER CHILLER

COOLING TOWER

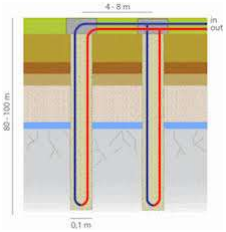


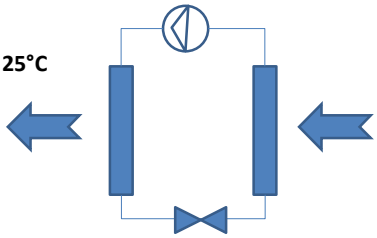


AQUIFER

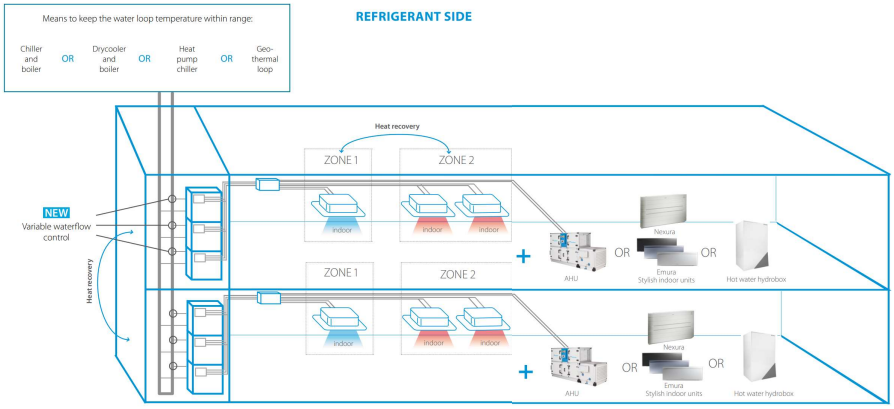


GROUND HEAT EXCHANGER

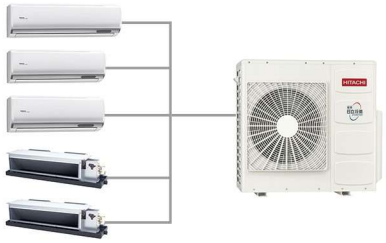


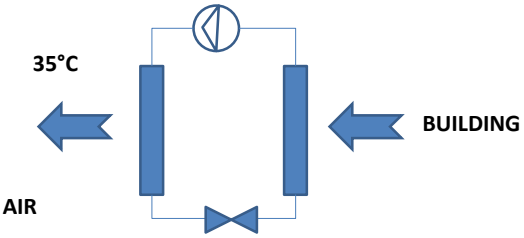


AIR TO WATER CHILLER

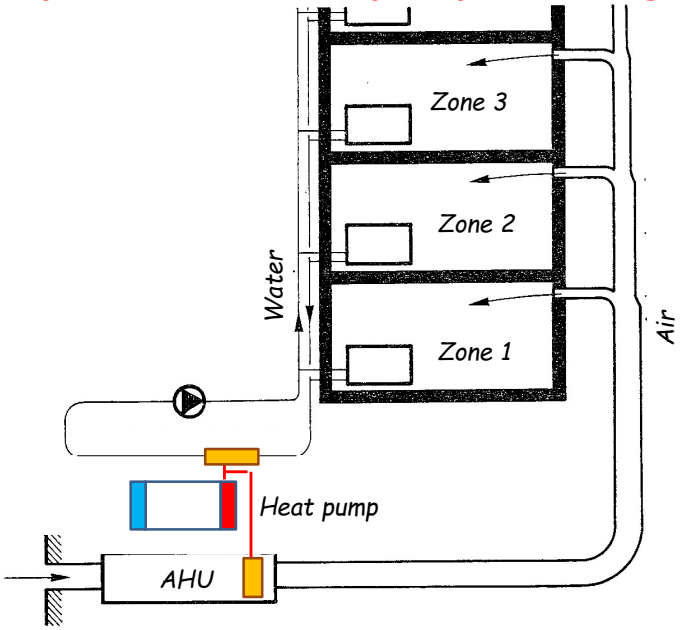


AIR TO AIR CHILLER



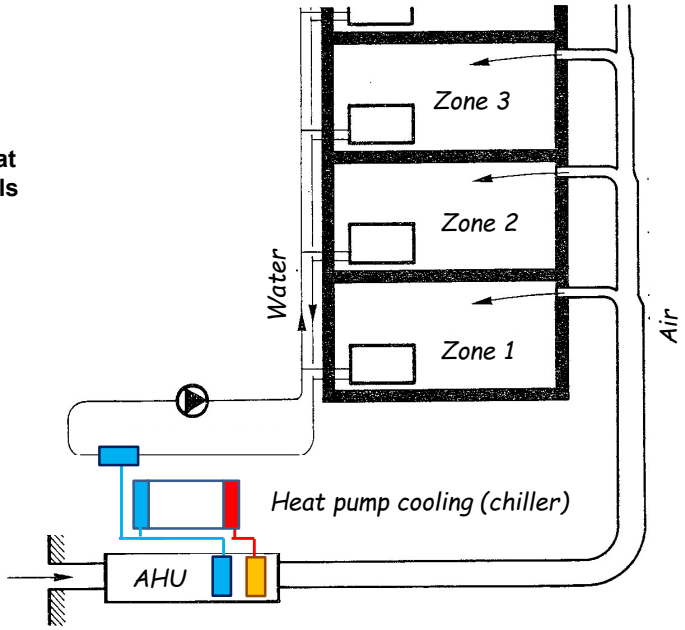


Air-water systems with heat pumps: heating



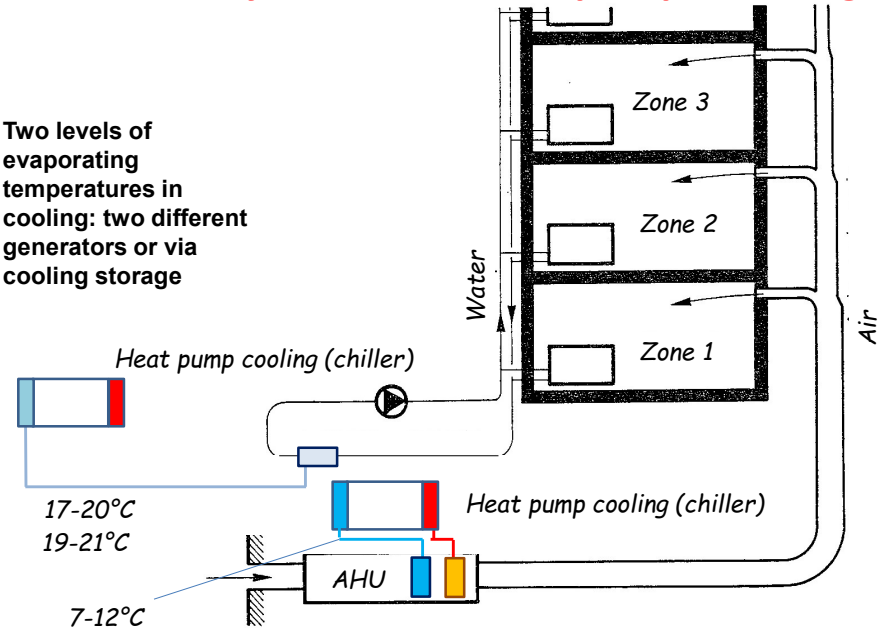
Air-water systems with heat pumps: cooling

Heat recovery: condensation heat for the reheat coils

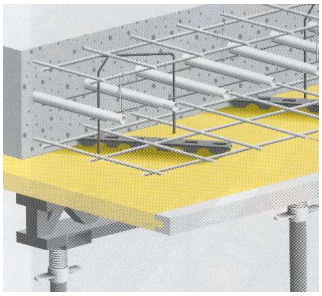


Air-water systems with heat pumps: cooling

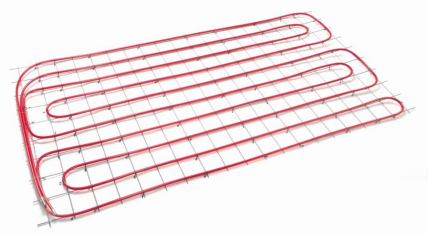
Two levels of evaporating temperatures in cooling: two different generators or via cooling storage



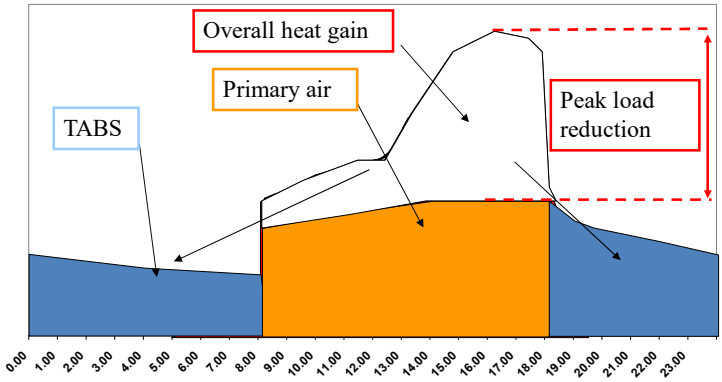
Example of energy storage in cooling: TABS (Thermo-Active Building System)



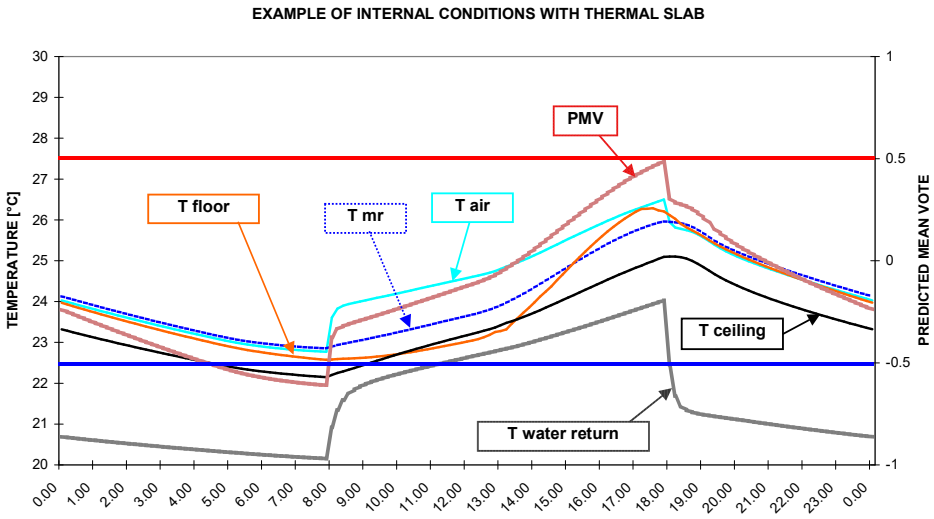
Pipes are embedded in the full concrete slab used also for structural purpose. It is also possible to use prefabricated elements easy to install on site.



Principle of operation of the TABS (Thermo-Active Building System)



Indoor conditions during a summer day

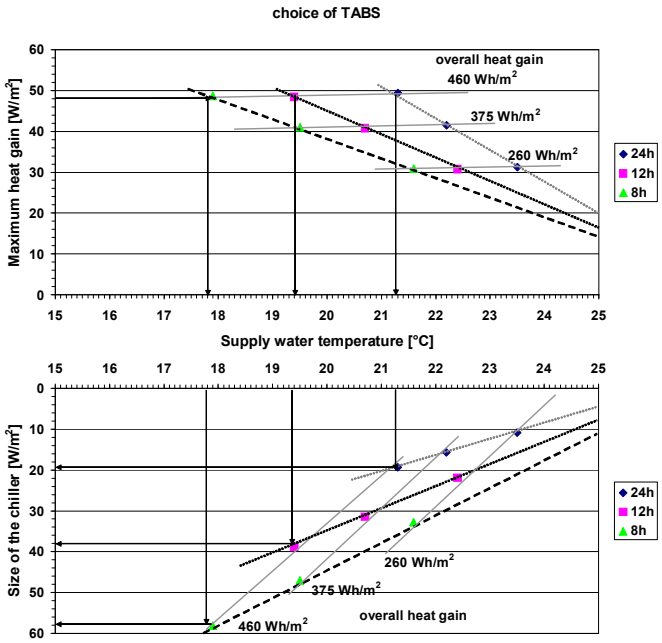


Advantages

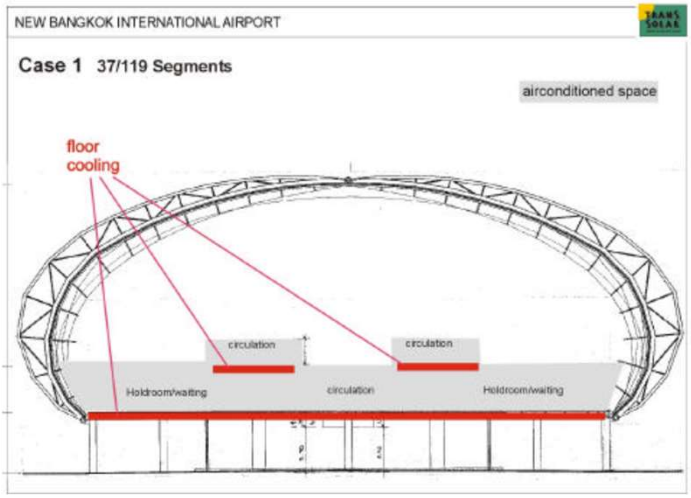
- Low temperature difference between water and room
- Limit in the peak power
- Possibility to operate at 2 different levels of temperatures (high COP during night)
- Working overnight electric energy could be cheaper

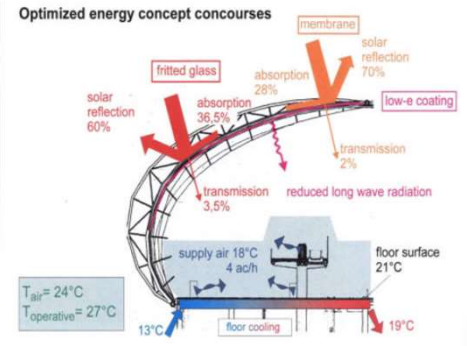
Critical aspects

- Optimization of the envelope (max. heat gain circa 55-60 W/m^2)
- Weight of structures
- Need to use dynamic simulations for fine tune sizing

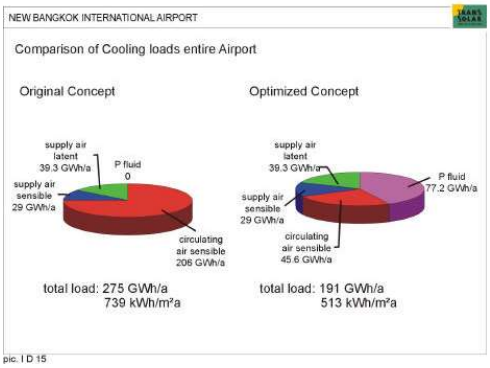


Another interesting application: radiant floor + displacement ventilation in large buildings

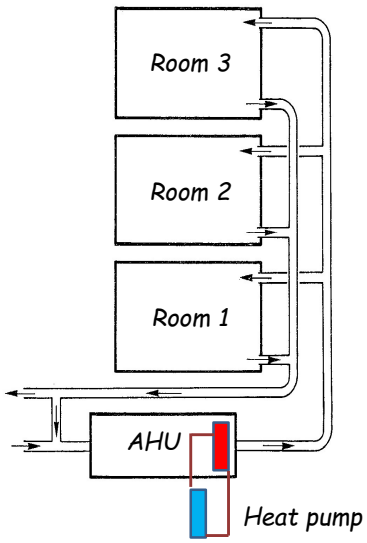




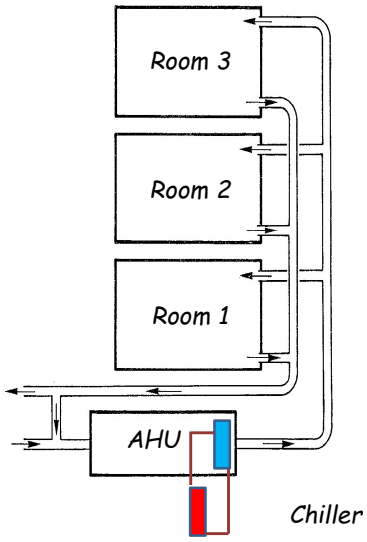
Energy saving: 30%

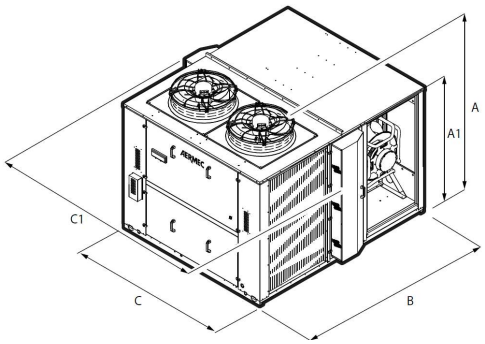


Air-Air systems with full air: rooftop solutions (heating)



Air-Air systems with full air: rooftop solutions (Cooling)





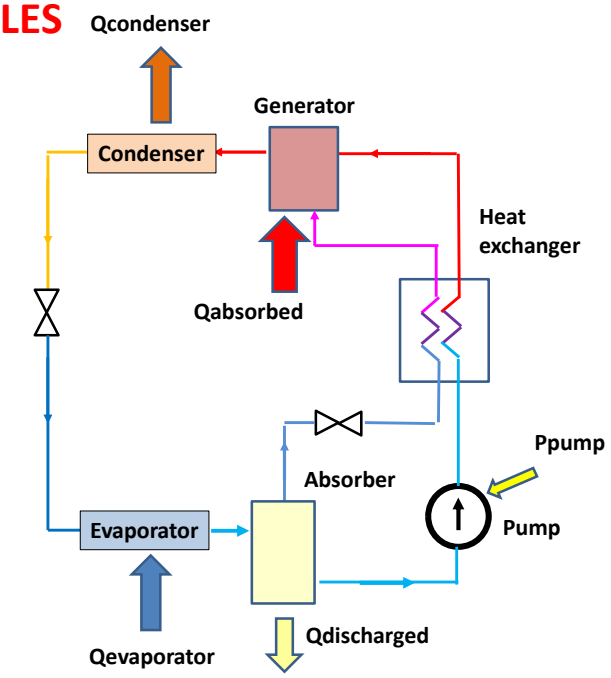
ABSORPTION CYCLES

Cooling cycle:

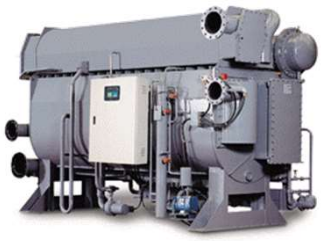
$$\text{Efficiency} = \frac{Q_{evaporator}}{Q_{absorbed}}$$

Heating cycle:

$$\text{Efficiency} = \frac{Q_{condenser}}{Q_{absorbed}}$$



ABSORPTION CHILLERS



Absorption chillers are able to use hot temperature source.
This can be solar thermal energy, energy waste, heat rejected by a cogenerator (trigeneration).
Usually the most common compound is Lithium Bromide (LiBr) coupled with water.

Usually the minimum temperature of the source should be 90°C.

The efficiency is related to the type of cycle; usually single stage machines are used with a typical value of COP = 0.7

These system can work only in cooling. In heating they are not able to operate as heat pumps.

ABSORPTION HEAT PUMP

Absorption heat pumps are mainly working today with natural gas. .
Usually the most common mixture is water-ammonia.

$$GUE = \frac{Qcondenser}{Qabsorbed}$$

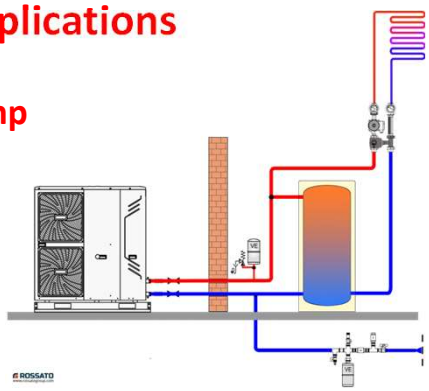
The typical efficiency is GUE = 1.4

These systems are optimized for working in heating conditions. They can work also in cooling conditions, but usually in cooling the performance is poor.

Residential applications

Monoblock air to water heat pump

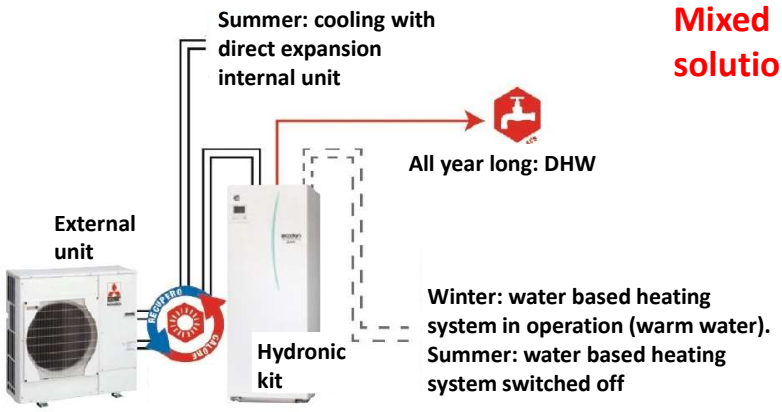
The whole machine is outdoor.
Cheap solution.
Need to provide antifreeze solution for the water of the plant.



Split air to water heat pump

Part of the machine is installed outdoor. More efficient solution.
Possibile plug&play solutions with integrated hydronic kit

Mixed solution



External unit which can provide heating and cooling.
An hydronic kit allows to generate DHW (with a tank) all over the year and in winter warm water for the radiant system.
In summer the system works as a usual direct expansion cooling system.