POLITECNICO DI MILANO

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

TASK 38
Solar Air-Conditioning and Refrigeration

Open sorption systems, desiccant air-handling units – market status and new developments

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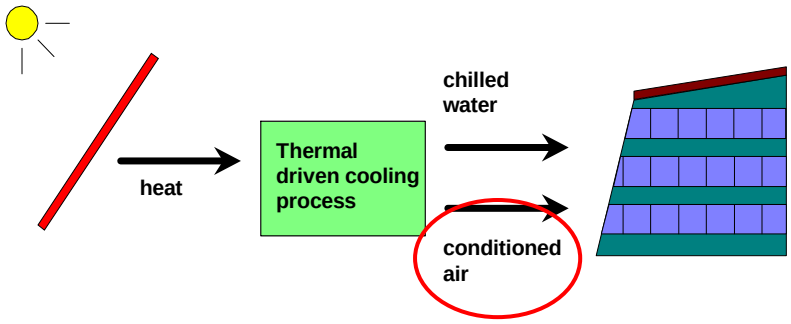
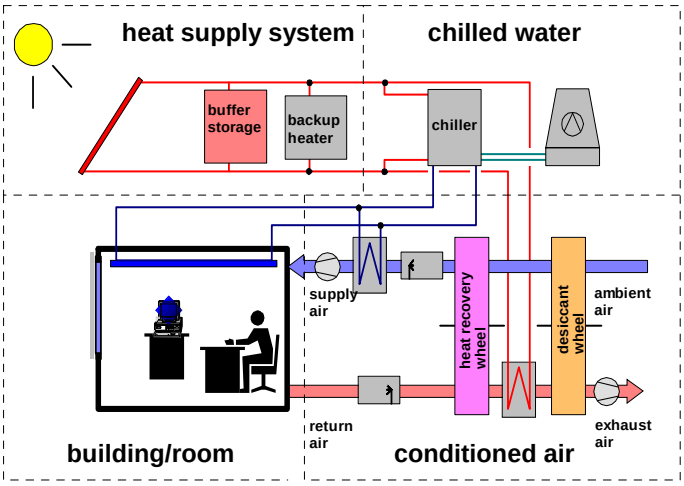
Workshop "Solar Air-Conditioning and Refrigeration"
Aix Les Bains

Basic process



DEC general scheme

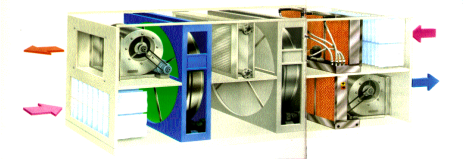


Desiccant and evaporative cooling systems Market available equipment

- desiccant systems are used for direct air treatment
- they generally consist of a combination of sorptive air dehumidification and evaporative cooling
- the potential to apply evaporative cooling is increased by air dehumidification
- a desiccant system replaces a conventional air handling unit to provide fresh air without using a conventional compression chiller

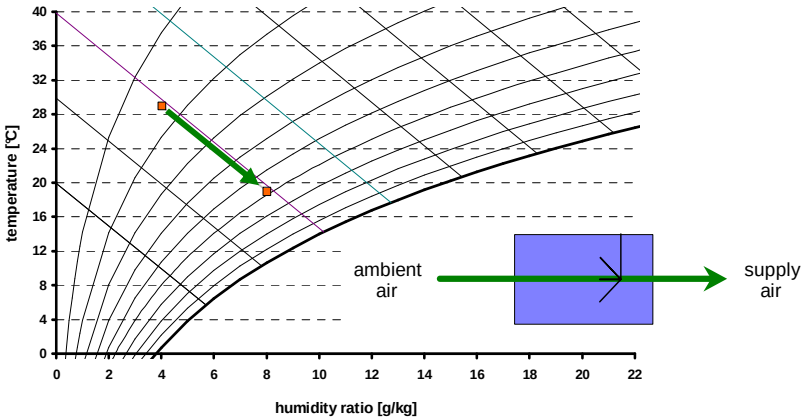
Desiccant cooling systems
Market available equipment

- two major technologies exist:
  - *systems with desiccant rotors:*
    desiccant rotors available in a broad range of sizes from several manufacturers; sorption material either silica gel or lithium-chloride; cycle adjustable to different climatic conditions

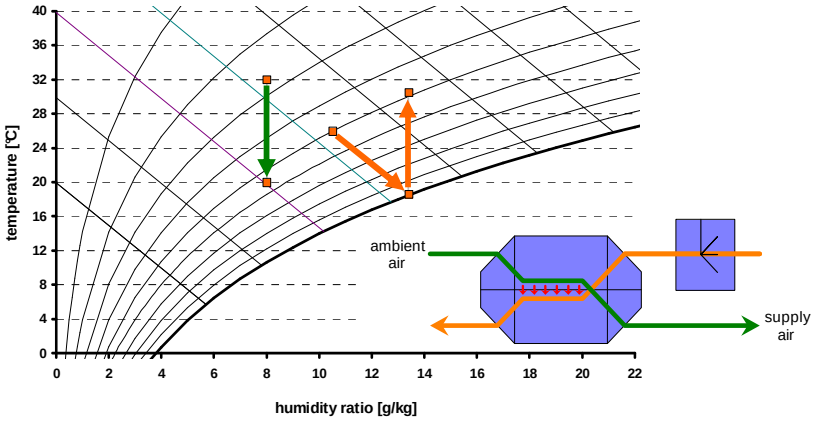


  - *systems using liquid desiccants:*
    few systems in pilot plant operation; in almost all cases LiCl as desiccant material

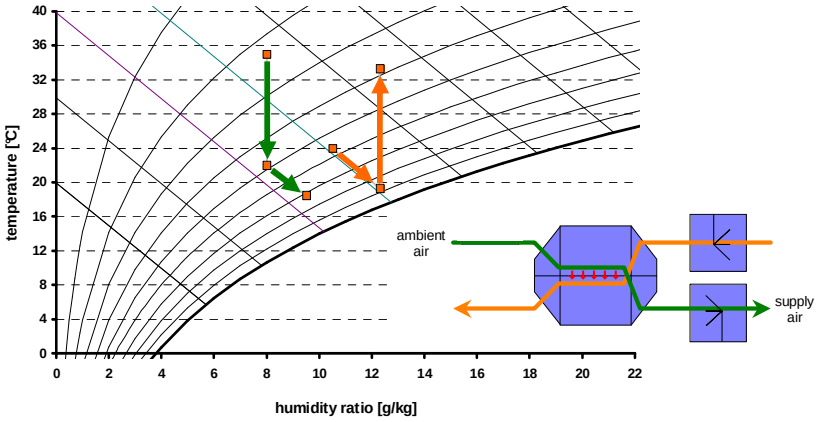
Basic process: direct evaporative cooling



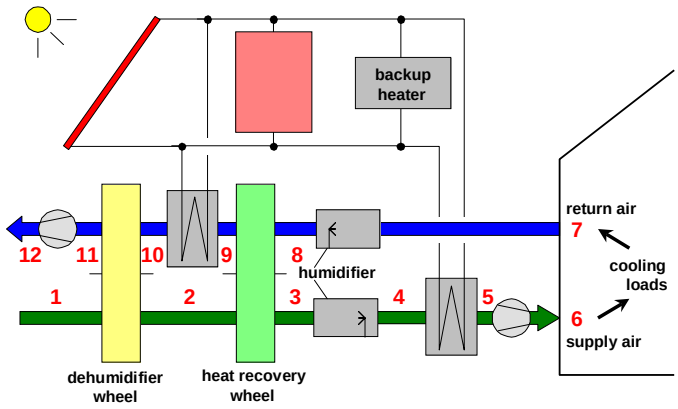
Indirect evaporative cooling



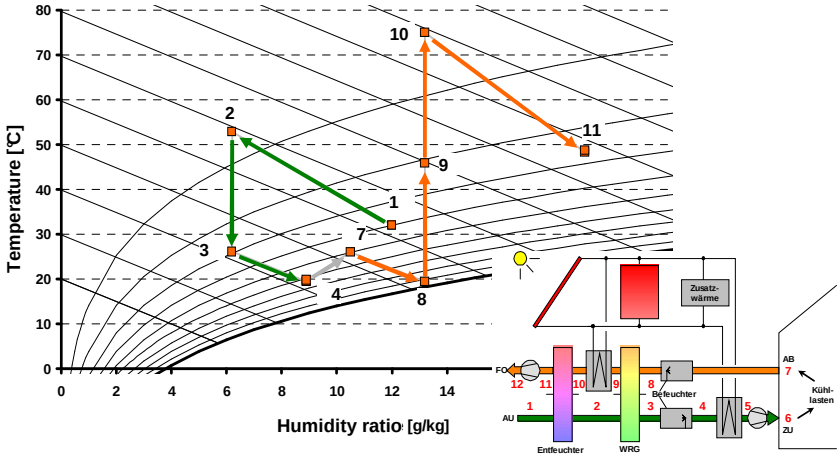
Combined evaporative cooling



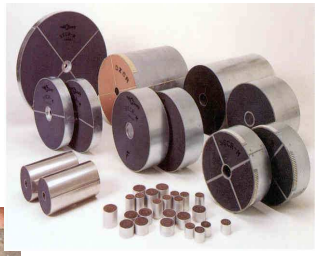
Standard DEC process (e.g., Continental Europe)



Standard DEC process for moderate climates (e.g., Centrale Europe)

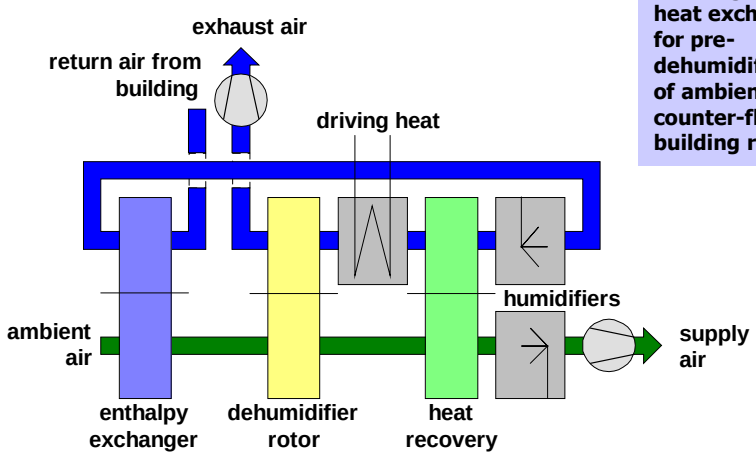


Desiccant wheels

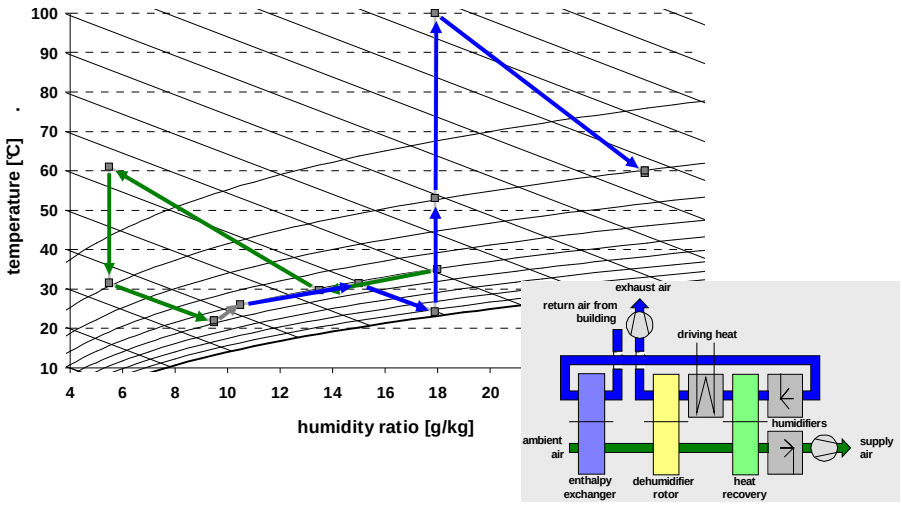


Modified scheme for humid climate (e.g., South Mediterrenean)

enthalpy exchanger (total heat exchanger) for pre-dehumidification of ambient air in counter-flow to building return air

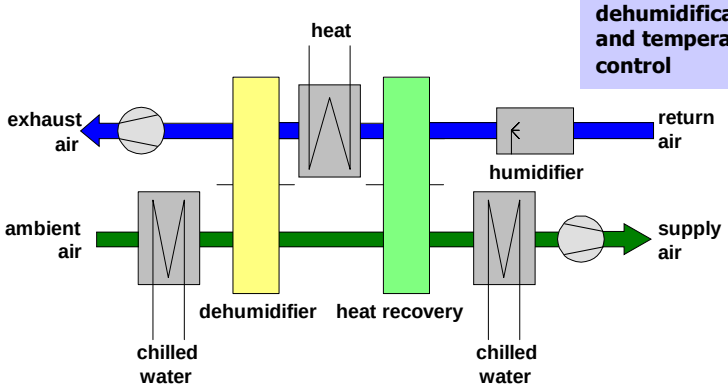


Modified scheme for humid climate (e.g., South Mediterrenean)



Scheme for very humid climates (e.g., Asia)

combination of standard system with cooling coils for pre-dehumidification and temperature control



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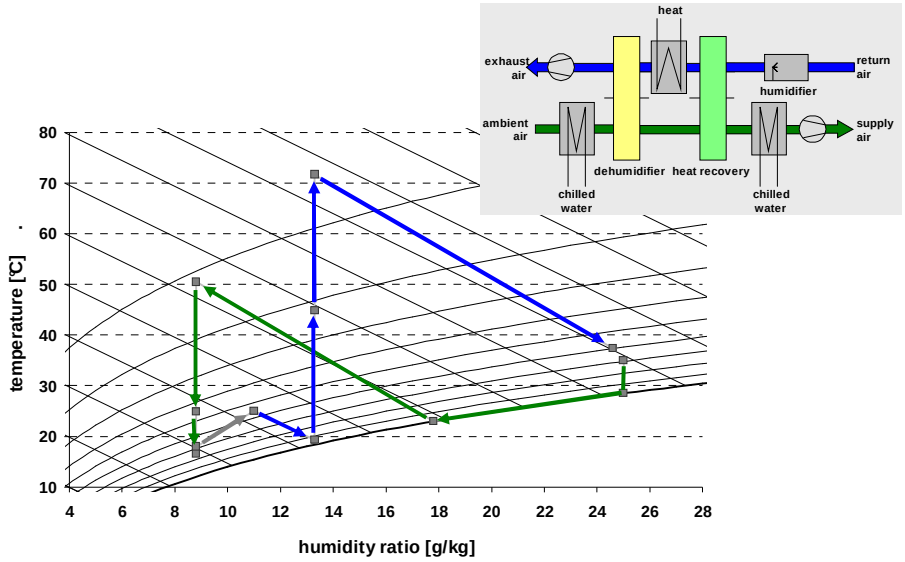
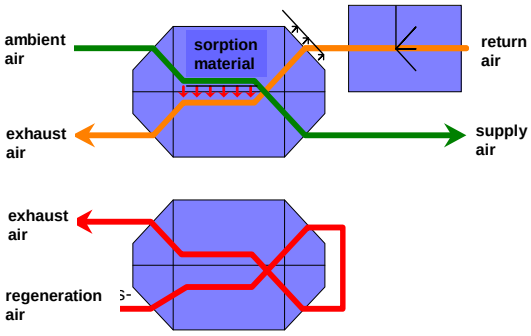
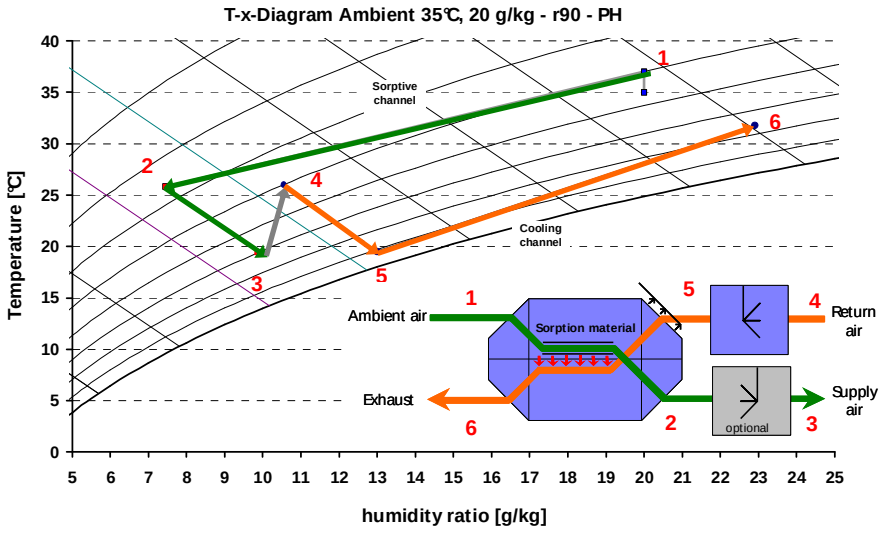


ECOS - indirect Evaporative COoling counter-flow heat exchanger with Sorption

- Objective: high dehumidification and cooling
- simultaneous sorptive dehumidification and cooling processes
- return continuously humidified while passing through the heat exchanger: best use of enthalpy uptake for indirect adiabatic cooling
- regeneration is realized with heated ambient air
- **periodical process** two heat exchangers in order to realize a quasi-continuous operation



ECOS – advanced desiccant and evaporative cooling



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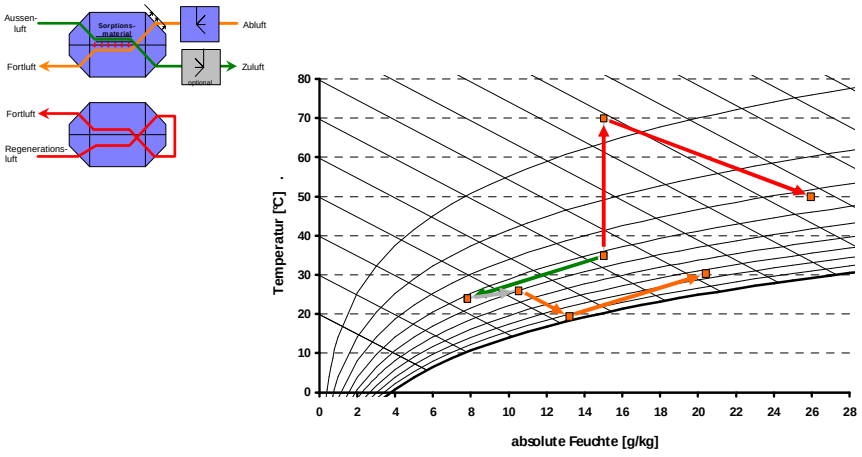
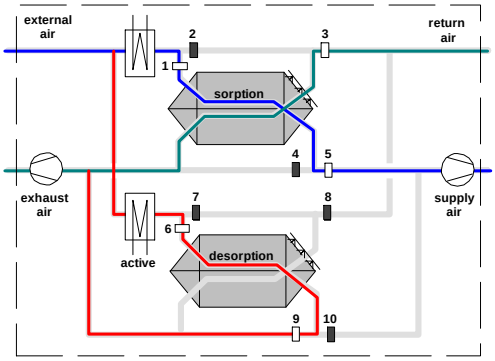


Complete system with two heat exchangers

A possible hydraulic design and operation sequence

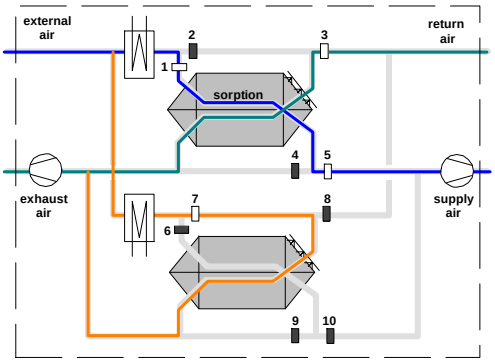
Phase 1:
Top:
cooled sorptive dehumidification
Bottom:
regeneration



Complete system with two heat exchangers

A possible hydraulic design and operation sequence

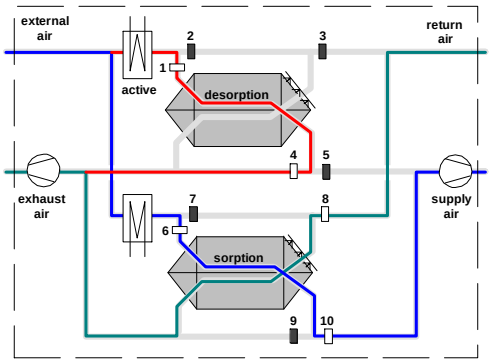
Phase 2:
Top:
cooled sorptive dehumidification
Bottom:
pre-cooling



Complete system with two heat exchangers

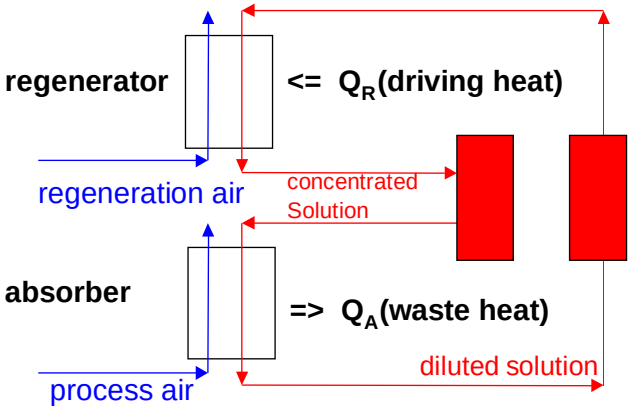
A possible hydraulic design and operation sequence

Phase 3:
Top:
regeneration
Bottom:
cooled sorptive dehumidification



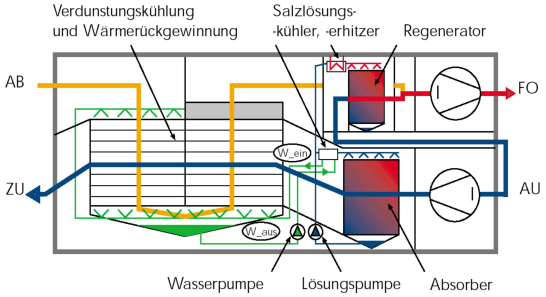
Principle of liquid sorption

- Open absorption
- Possibility to store energy through regenerated solution
- Possible shift between radiation availability and regeneration
- Pilot plants in Germany and Israel



Advantage of liquid sorption

- the absorption process is cooled; thereby a higher dehumidification is possible using the same driving temperatures (typically 55 - 75 °C)



- the concentrated solution can be used as high-efficient storage; thereby a mismatch between regeneration (solar gains) and dehumidification (cooling loads) can be overcome

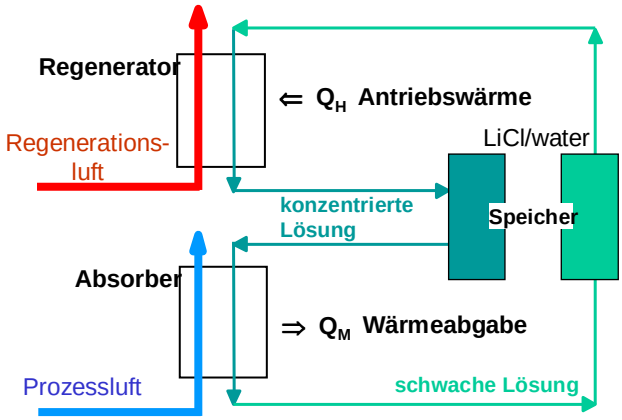
Thank you for your attention !!!

Conclusions

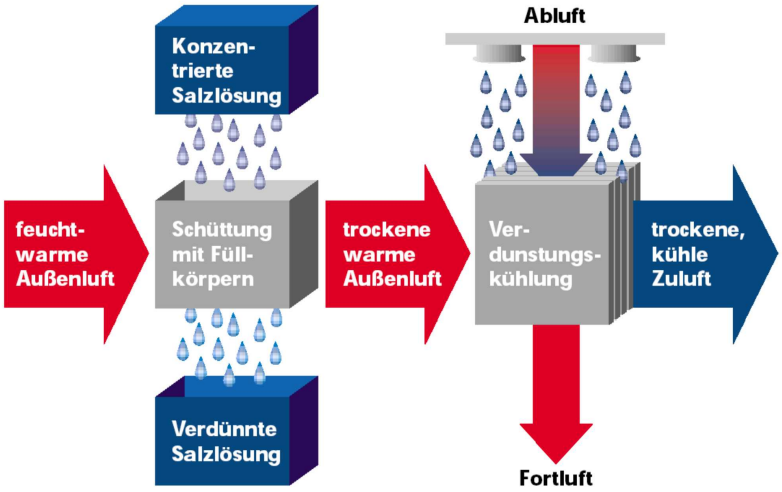
- Open cycles based on solid sorbents are particularly suitable for solar assisted air-conditioning system applications where a ventilation system (all air or hybrid distribution) is compulsory
- DEC's using rotors still high extra costs but the market potential results significant for large capacity applications (>10.000 m^3/h)
- Several new developments employing solid and liquid DEC. Could have high potential for small capacity applications.

Thank you for your attention !!!

Offene Systeme mit Flüssigsorption

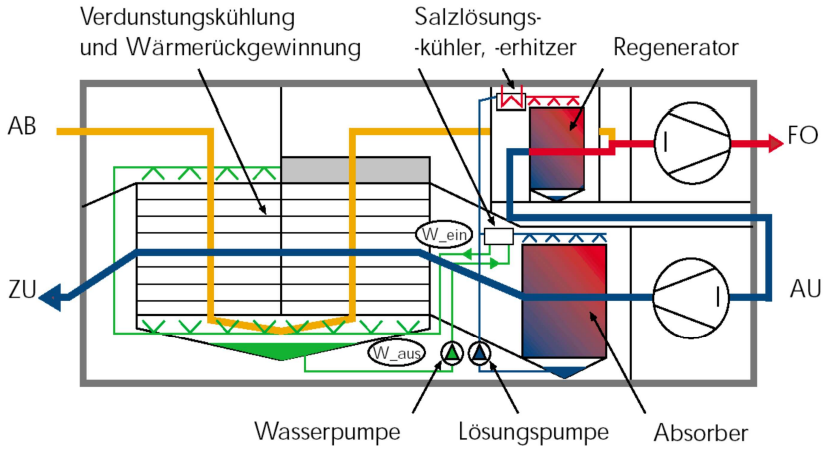


Offene Systeme mit Flüssigsorption - Prinzip



Prototyp eines Lüftungsgerätes mit Flüssigsorption

Lüftungsgerät mit indirekter Verdunstungskühlung und sorptiver Entfeuchtung (Fa. Menerga)



Menerga System

Sistema DEC per una biblioteca

- Sito: Mataro/Spagna
- Utente: Biblioteca pubblica
- Tipologia: Sistema DEC (12000 m^3/h) con 105 m^2 collettori ad aria e pre-riscaldamento attraverso facciata fotovoltaica
- Utilizzo: Climatizzazione centro audiovisivi (2.120 m^3)

Condizionamento sala seminari Friburgo (Germania)

Condizionamento sala seminari

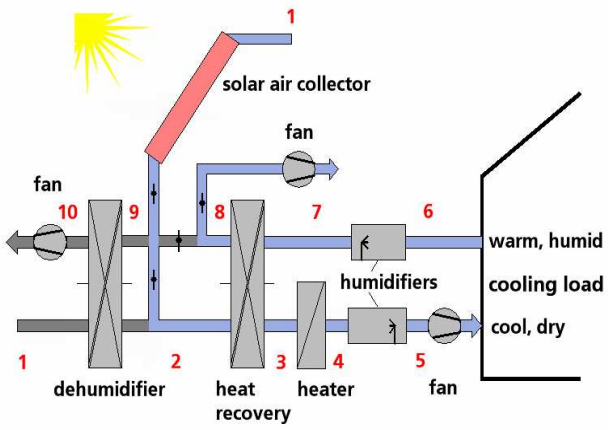
- Collettori solari ad ariacome unica fonte di calore: 100 m^2
- Sistema DEC (10.200 m^3/h) con rotore al gel silicato
- no sistema back-up
- Condizionamento sala seminari (piccola sala riunioni) presso l'edificio della camera di commercio di Friburgo/ Germania

➔ Sistema solare semplificato e semplice integrazione con l'impianto di condizionamento

➔ no back-up, no serbatoio

➔ Schema promettente per edifici con alta correlazione tra carichi di condizionamento e radiazione solare

Funzionamento invernale



Funzionamento estivo