Solar Air-Conditioning and Refrigeration - Introduction

Hans-Martin Henning
Fraunhofer-Institut für Solare Energiesysteme ISE,
Freiburg/Germany

Workshop “Solar Air-Conditioning and Refrigeration”
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Solar Air-Conditioning and Refrigeration

Overview

- Introduction
- Technologies
- Status, Examples
- Outlook

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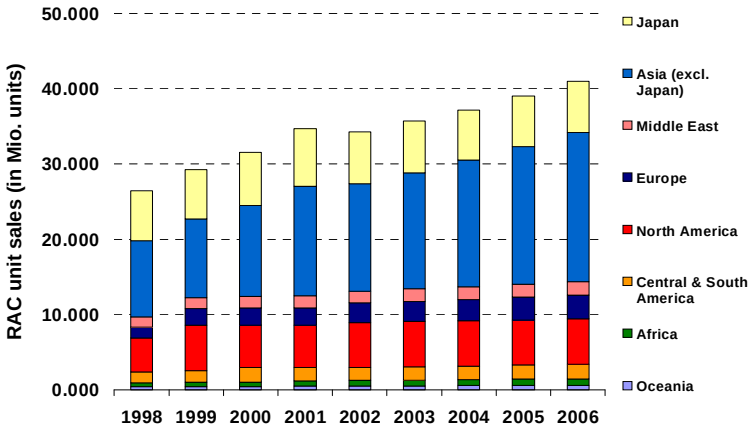
World market for air-conditioning



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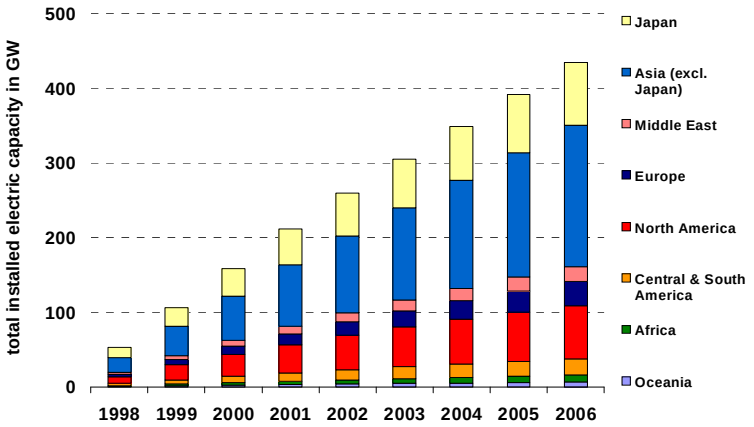
Resulting increase in electric capacity



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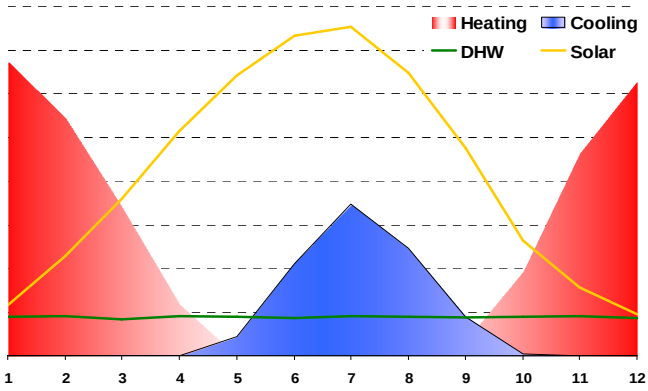
Why solar heat for cooling / air-conditioning?

- Coincidence of solar gains and cooling loads
- Reduce electric peak loads created by air-conditioning
- High use of solar gains during the entire year
- Reduce summer surplus solar gains in solar systems designed for heating application (solar combi-systems)



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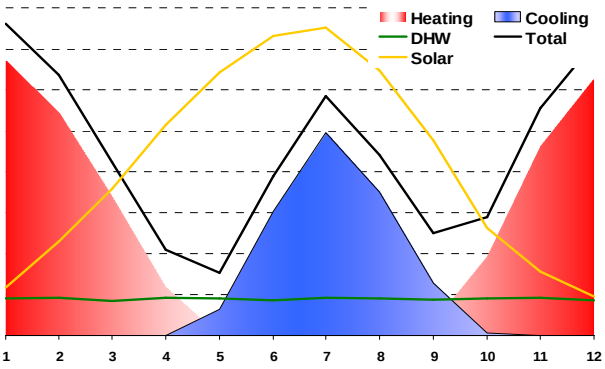
$$COP = \frac{\text{useful cooling}}{\text{driving heat}} = 0.7$$



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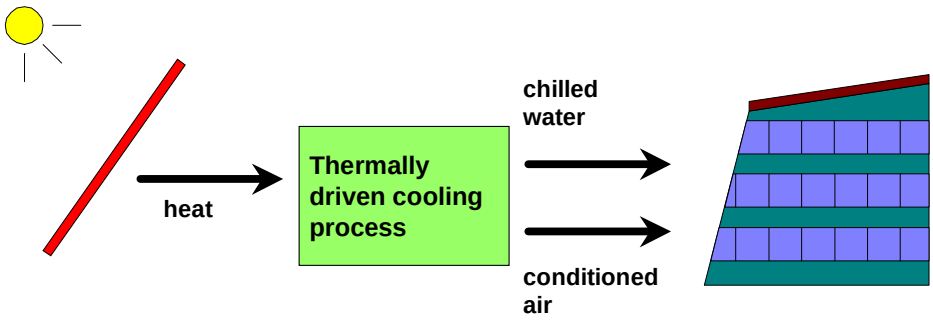
Basic system scheme



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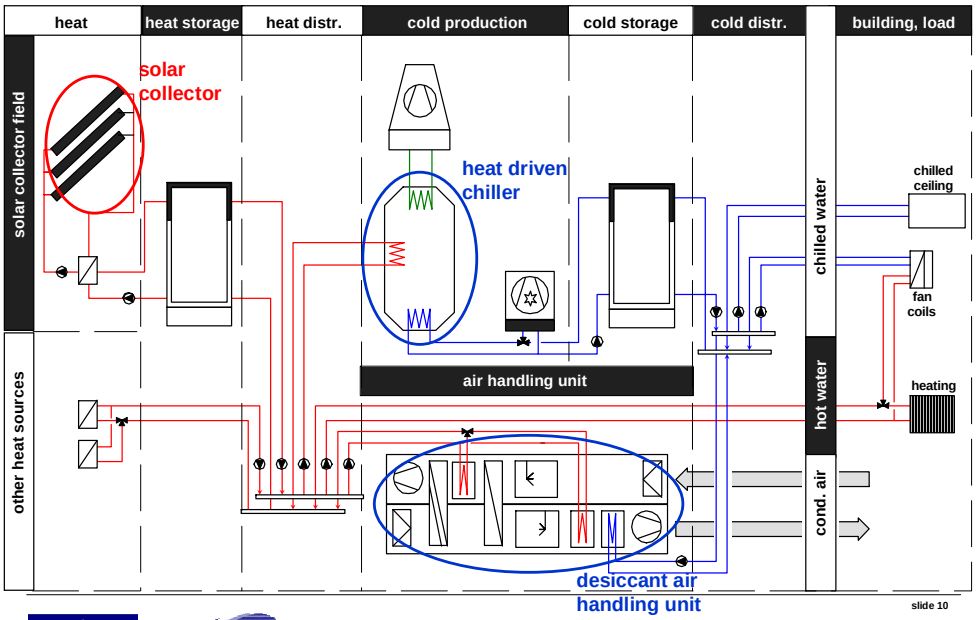

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Small thermally driven water chillers – new products entering the market

aosol

EAW

rotartica

SorTech AG

PINK

ClimateWell

SK SonnenKlima GmbH

Desiccant systems

- Air handling units using heat driven air dehumidification

System using desiccant wheel

System using liquid desiccant

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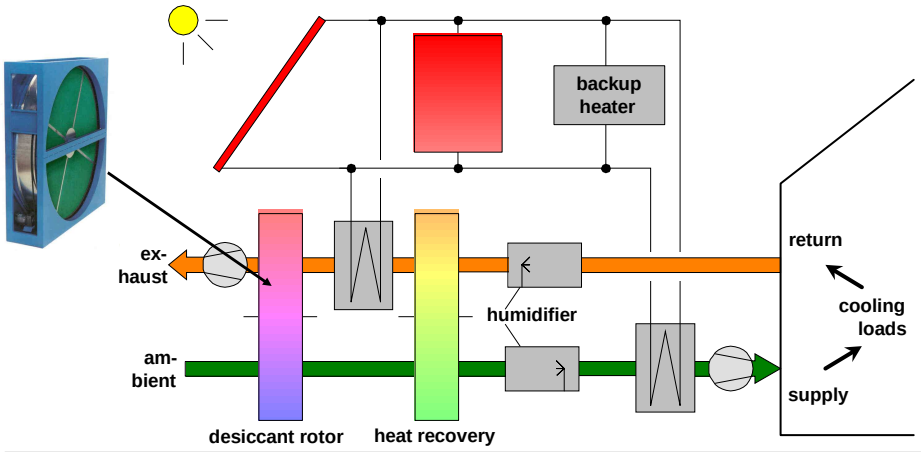
Desiccant system schematic



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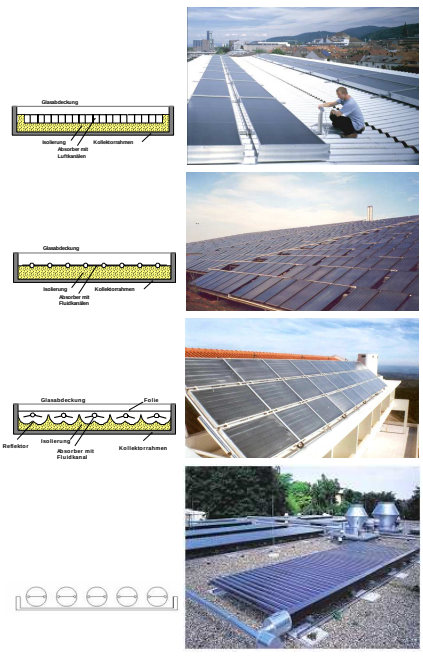
Temperature needs

- **Desiccant systems: 50 – 80℃**
  - Solar air collectors, flat plate collectors
- **Adsorption: 65 – 85℃**
  - Flat plate collectors, evacuated tubes
- **Single-effect absorption (comfort air-conditioning): 70 – 100℃**
  - Flat plate collectors, evacuated tubes, optical concentration without tracking
- **Double-effect absorption: 130-160℃**
  - High efficient evacuated tubes, optical concentration with tracking



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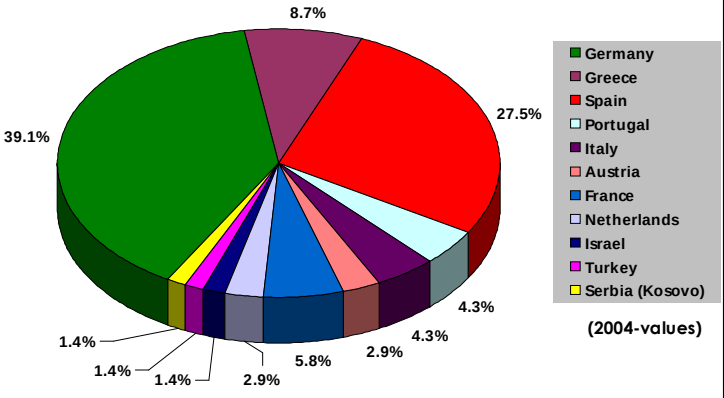
Status in Europe

- **Approx. 120 installations**
- **Approx. 20 MW_{cold} installed**
- **Specific collector area**
  - 3 m^2/kW_{cold} for chilled water production
  - 10 m^2 per 1000 m^3/h for sorptive air handling units



(2004-values)

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Air-conditioning of a factory

- flat plat collector **field:** 2700 m^2
- **2** adsorptions chillers **with** 350 kW **cooling capacity each**
- **3 compression chillers with 350 kW each**
- **air conditioning of the production facilities of a cosmetics factory**
- **site: Inofita Viotias (appr. 50 km north-east of Athens)**
- **largest system today**

➔ interesting system concept: electricity saving by solar cooling

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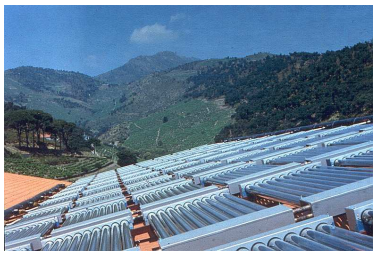
Wine store cooling

- evacuated tube collector **field:** 130 m^2
- single-effect absorption chiller **with** 52 kW **cooling capacity**
- **no back-up system**
- **cooling of a wine store (about 3 million bottles) with 3 air handling units (25.000 m^3/h air flow)**
- **site: Banyuls (south France)**
- **one of the oldest systems; operates more than 12 years without problems**

➔ solar autonomous and not buffer storage ==> storage on load side



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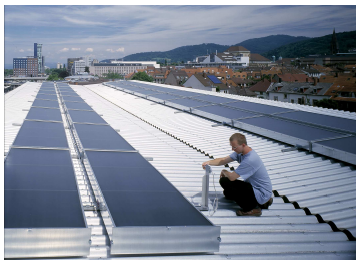
Air-conditioning of a seminar room

- solar air collector **as only heat source:** 100 m²
- desiccant cooling system **(10.200 m³ per hour) with silica gel rotor**
- **no back-up system**
- **air-conditioning of the seminar room and the cafeteria in the building of the chamber for trade & commerce in Freiburg/ Germany**
- **simple solar system with simple integration into the air-conditioning plant**
- **no back-up, no storage**

➔ promising concept for buildings with a high similarity of cooling loads and solar gains



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Hotel air-conditioning

- parabolic trough collector **produces heat at 180°C:** 180 m² **aperture area**
- double effect absorption chiller **(cooling capacity** 116 kW**, 4 bar saturated steam; COP > 1.2)**
- **air-conditioning of a hotel and steam supply for the hotel laundry**
- **LPG-fired back-up steam boiler**
- **site: Dalaman (mediterranean coast Turkey)**

➔ first system with double effect chiller

➔ high overall conversion efficiency

➔ interesting concept for sites with high direct radiation

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Status

- **Energy saving**
  - Primary energy saving for properly designed chilled water systems 40 – 60 %
  - Primary energy saving for properly designed open cycles 20 – 50 %
- **First cost**
  - 2 – 2.5 times higher compared to conventional reference systems
- **Overall annual cost**
  - 1.2 – 1.5 times higher compared to conventional reference systems
  - Close to break-even with funds in the range of 100 € per m^2 of collector

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- **Large potential, in particular in mediterranean countries**
- **Potential for cost reduction**
  - Higher standardization
  - Less effort in planning and design
  - Lower component cost

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… thank you for your attention!

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Water chillers - market available systems

water chillers produce chilled water which can supply any type of air-conditioning equipment (e.g. air handling units, fan-coils, chilled ceilings,....)

single-effect absorption	many products for cooling power > 100 kW; few products <100 kW; refrigerant/sorption pair either water/LiBr or ammonia/water
double-effect absorption	several manufacturers; often direct fired systems; no products <100 kW; refrigerant/ sorption pair in most cases water/LiBr
adsorption	a few commercially available systems (Asia); refrigerant/sorption pair water/silica gel
steam jet cycle	tailor-made sytems for large capacities; refrigerant water

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Desiccant systems - market available equipment

- **desiccant systems are used for direct air treatment**
- **they consist of a combination of sorptive air dehumidification and evaporative cooling**
- **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
    - LiCl as desiccant material

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