Do we need energy storage?

The Solar Heating & Cooling perspective

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

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Fraunhofer-Institute for Solar Energy Systems ISE

Energy Storage: Matching Supply and Demand in the Future

IEA ECES Workshop
July 14-16, 2010
Bad Tölz, Germany

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Outline

- The IEA Solar Heating & Cooling Programme
- Cold storage
- Heat storage
- Summary

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Solar Heating & Cooling Implementing Agreement

SOLAR HEATING & COOLING PROGRAMME
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www.iea-shc.org

- Established in 1976
- Works on technologies that use the energy of the sun to heat, cool, light and power buildings
- 19 countries + European Commission
- Mission: “To facilitate an environmentally sustainable future through the greater use of solar design and technologies.”
- International co-operation on a Task sharing basis
- Chairman Werner Weiss (AEE Intec, Austria, since June 2010)

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Ongoing Tasks

#	Task Name
37.	Advanced Housing Renovation with Solar & Conservation
38.	Solar Air-Conditioning and Refrigeration
39.	Polymeric Materials for Solar Thermal Applications
40.	Towards Net Zero Energy Solar Buildings
41.	Solar Energy and Architecture
42.	Compact Thermal Energy Storage (jointly with ECES – Energy Conservation through Energy Storage Programme)
43.	Solar Rating & Certification Procedure
44.	Systems Using Solar Thermal Energy in Combination with Heat Pumps (jointly with HPP – Heat Pump Programme)

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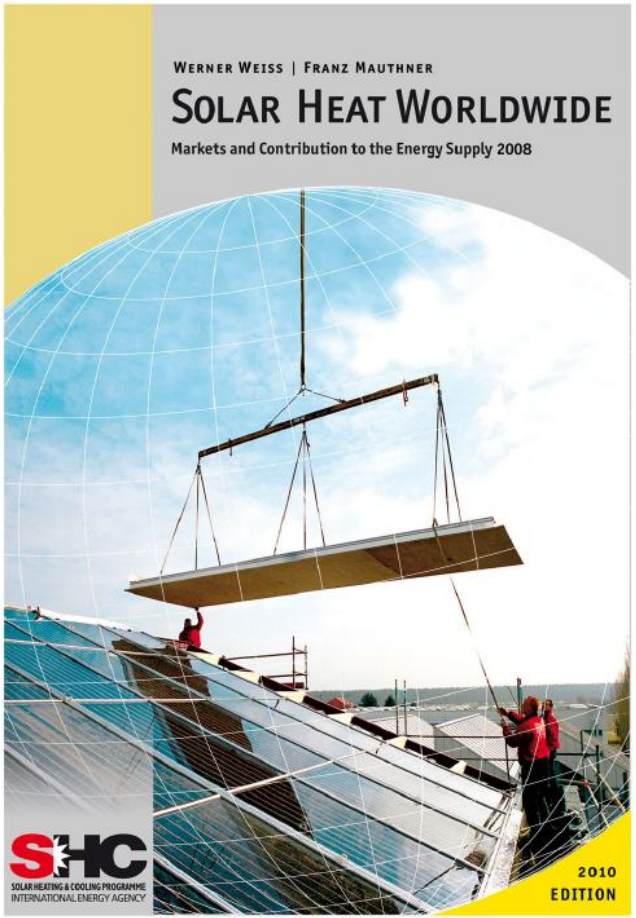
Solar Heat Worldwide



- Annual report on global market development
- Covers about 85-90 % of the solar low temperature world market

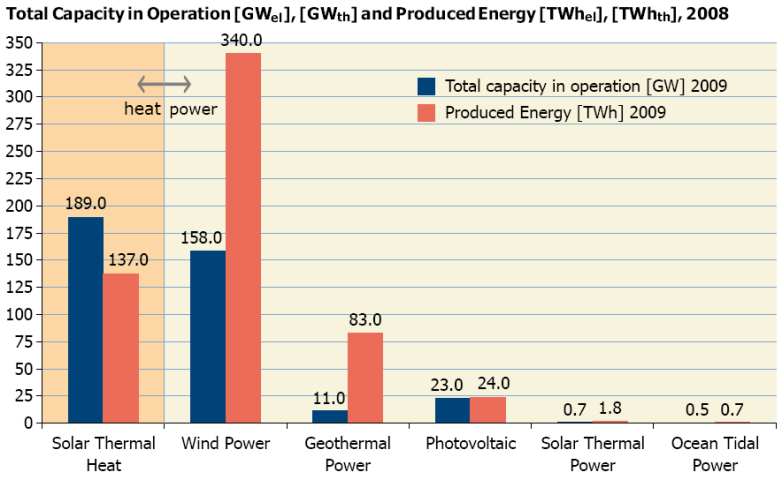


Figure 2: Total capacity in operation [GW_{el}], [GW_{th}] 2009 and annually energy generated [TWh_{el}], [TWh_{th}]. Sources: EPIA, GWEC, EWEA, EGEC, REN21 and IEA SHC 2009

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EuroSun 2010 – International Conference on Solar Heating, Cooling and Buildings

Topics

1. Solar Energy in Architecture
2. Net Zero Energy Buildings
3. Energy efficiency in buildings through solar application
4. Large-scale Solar Thermal Applications
5. Advanced solar domestic hot water heating
6. Solar Space Heating with high solar fraction
7. Solar Energy for Industrial and commercial Applications
8. Solar Cooling and Air Conditioning
9. Solar Collector Technology
10. **Thermal Energy Storage**
11. Engineering and Simulation Tools
12. Testing and certification
13. Solar radiation and solar energy availability

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ISES International Solar Energy Society

PSE projects in solar energy

AEE INTEC

Graz, Austria

September 28 – October 1, 2010

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Cooling – storage needs

- Energy-efficient cooling concepts using heat sinks of the environment (in particular for temperate climates)
  - ➔ Storage need: limited capacity, low air T's during night (some hours to day-night)
- Solar thermally driven cooling processes
  - ➔ Storage need: mismatch in time between cooling loads and solar gains (some hours to day-night)
- Conventional cooling equipment
  - ➔ Storage need: operation of equipment following energy tariffs and/or advanced performance conditions (lower heat rejection temperatures during night) (hour – day-night)

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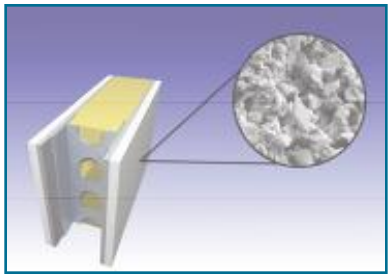
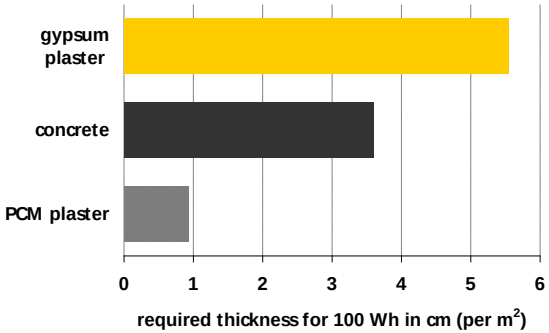
Energy efficient cooling concepts





- Heat sinks in the environment
  - Ground (tubes, horizontal HXs)
    - Limited capacity (power) ➔ operation decoupled from demand
    - Need for low-temperature storage
  - Outside air during night
    - Need for building integrated storage
- Storage concepts
  - Building thermal mass (thermally activated concrete slabs)
  - Building components with phase change materials (PCM)
  - Phase change slurries (PCS)

Quelle: BASF

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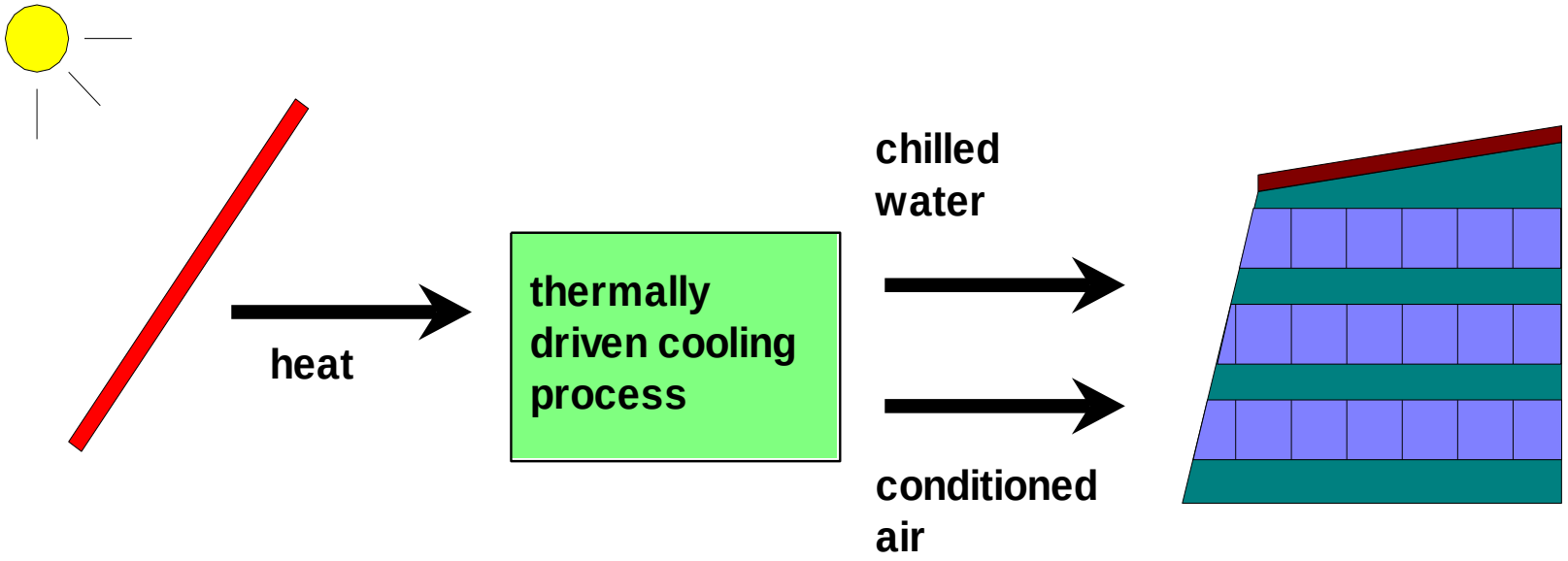
Solar thermally driven cooling



- Technical solutions
  - Cold water production (absorption, adsorption, other thermodynamic cycles)
  - Direct treatment of ventilation air (solid desiccant, liquid desiccant)
- Storage need: mismatch between solar gains and cooling loads

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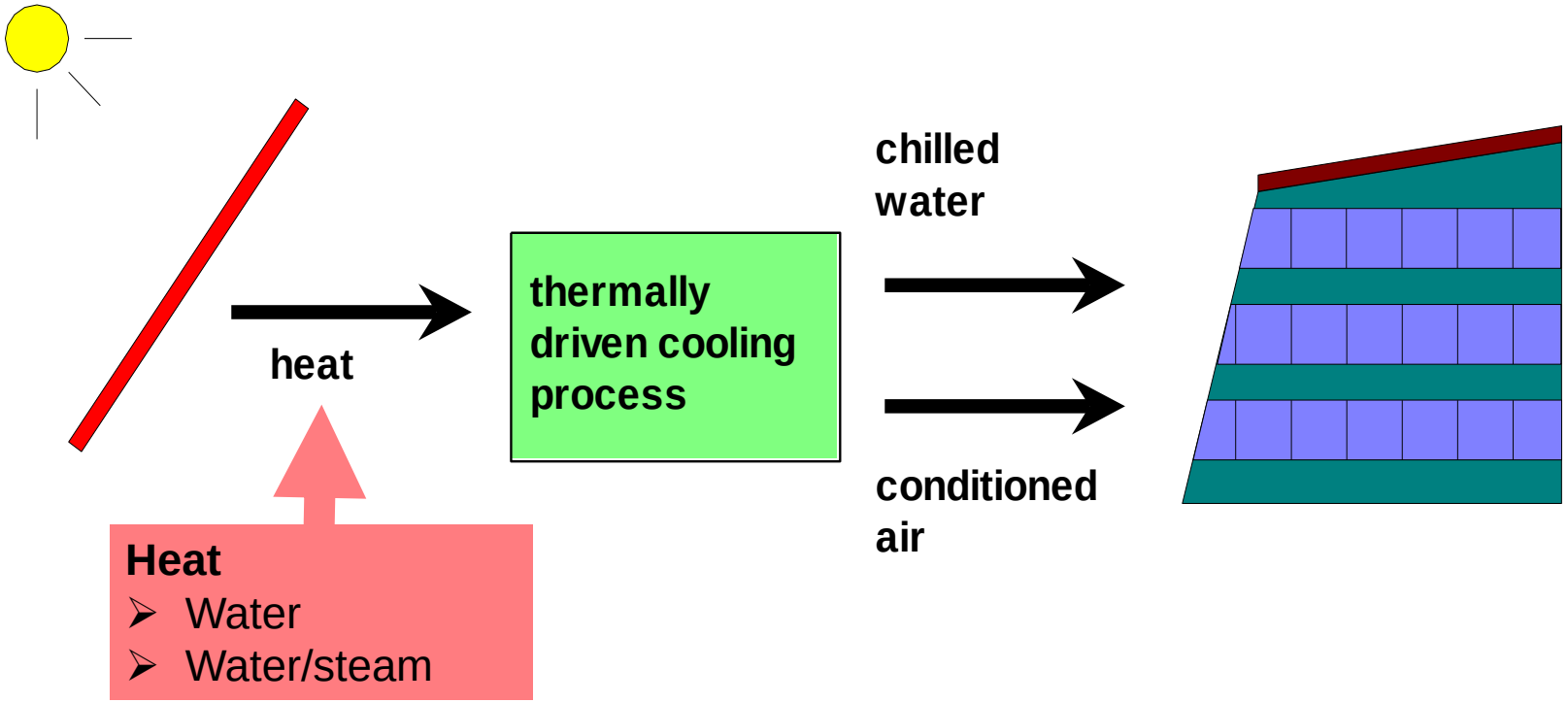
Solar thermally driven cooling



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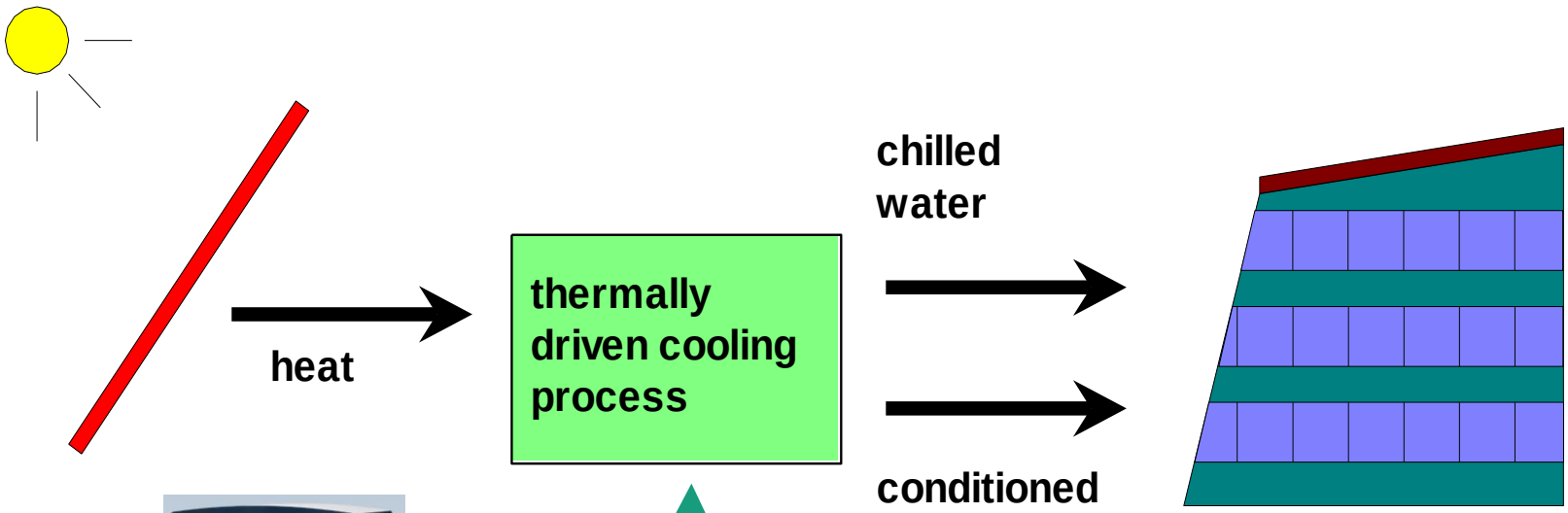
Solar thermally driven cooling



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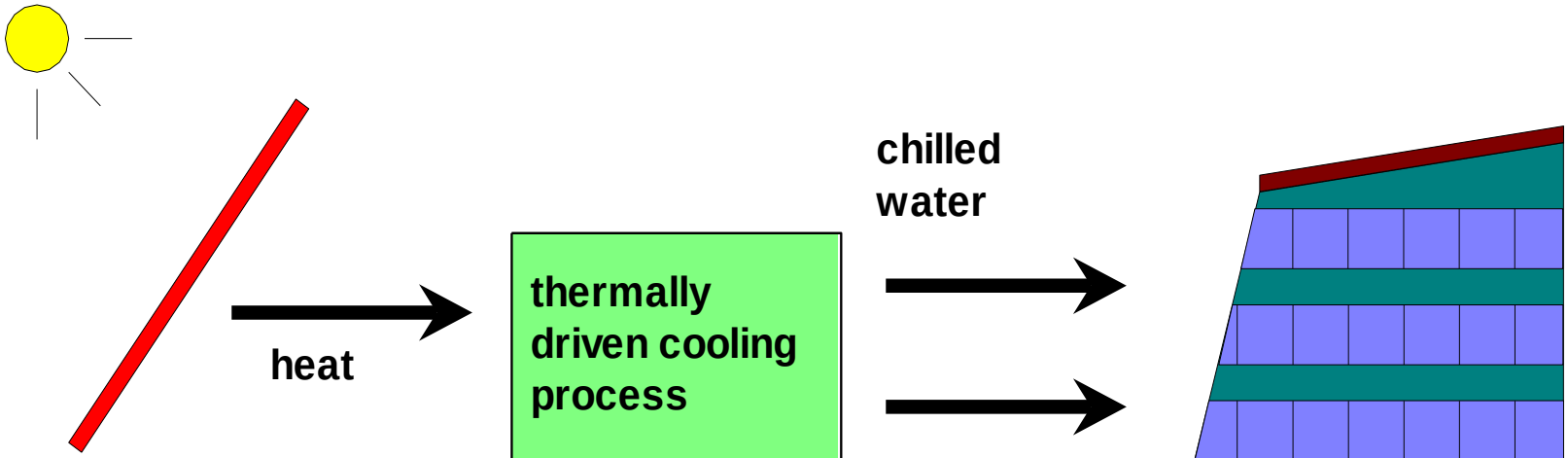
Solar thermally driven cooling



Chemical energy

- Concentrated sorption material

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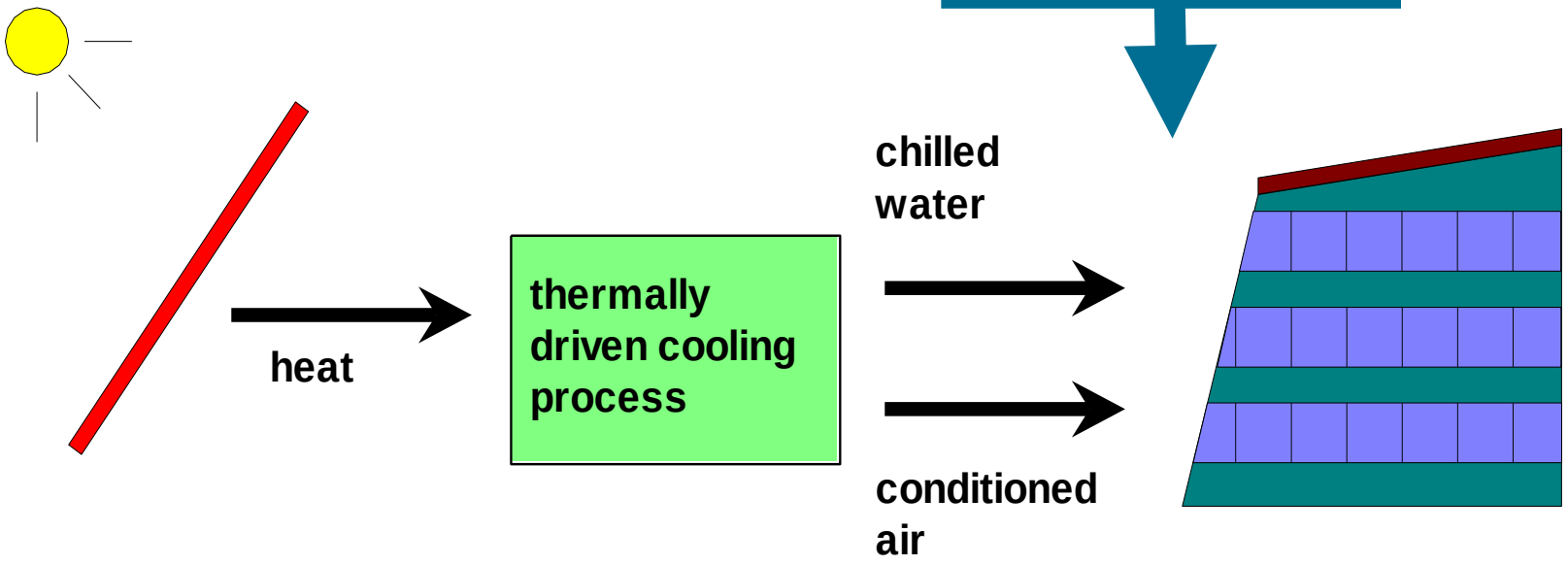
Solar thermally driven cooling

Cold side
- Chilled water
- PCM (slurry)
- Ice (solid, slurry)



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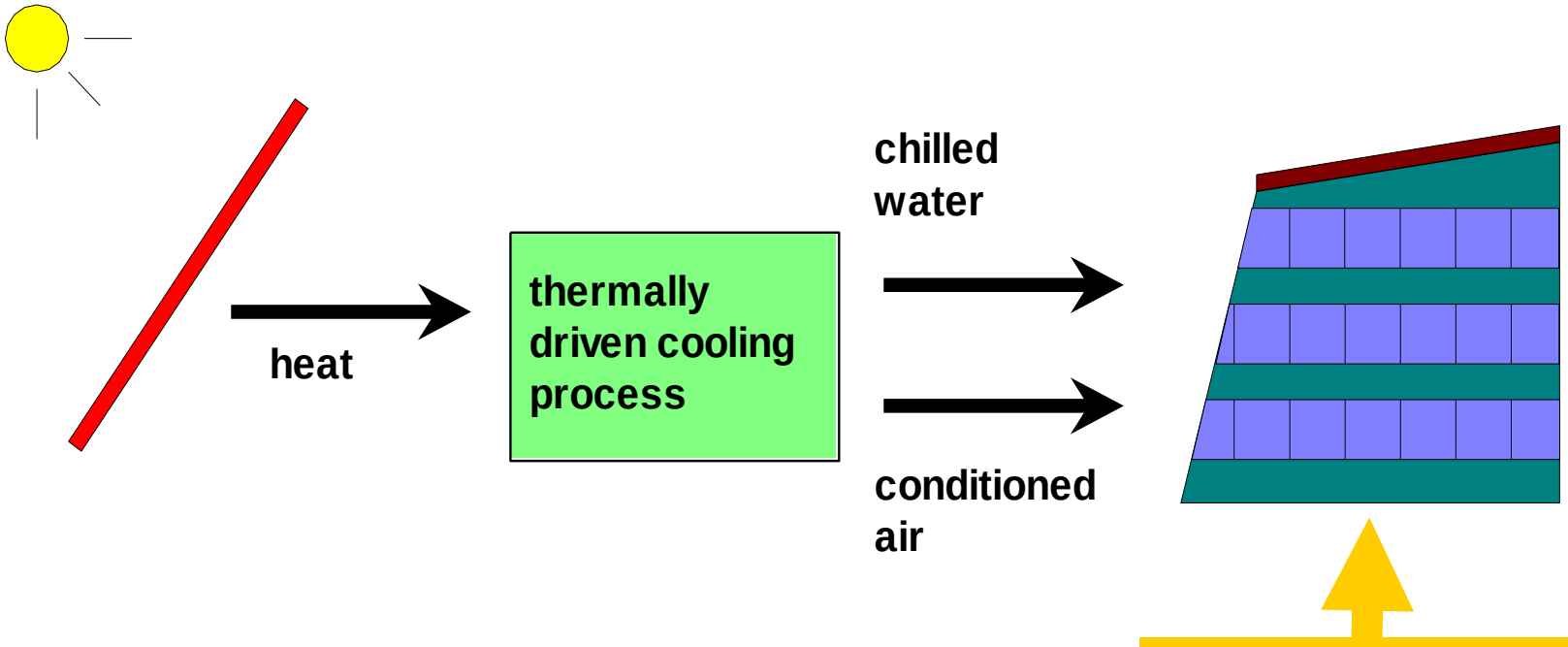
Solar thermally driven cooling



Building integrated

- Thermally activated building components
- Building integrated PCM

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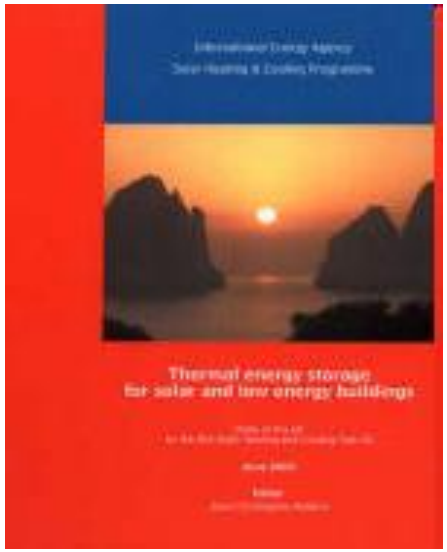
Two recent IEA SHC Tasks address(ed) heat storage

- Task 32: Advanced Storage Concepts for Solar and Low Energy Buildings
  - Subtasks
    - A: Evaluation and Dissemination
    - B: Chemical and Sorption
    - C: Phase Change Materials
    - D: Water
  - Main focus
    - Comparison of concepts under well defined boundary conditions
    - Development of performance figures
    - Further development on technology level



- SHC Task 42 / ECES Annex 24: Compact Thermal Energy Storage

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Heat – storage needs

- Solar domestic hot water systems
  - ➔ Storage need: mismatch between solar gains and DHW demand (hours to 1 day)
- Solar combi-systems: DHW + heating
  - ➔ Storage need: save solar heat for periods with heating demand (some days to a few weeks)
- Solar heating systems
  - ➔ Storage need: save solar heat from summer period to heating season (long-term, seasonal storage)
- Energy efficiency concepts (e.g. heat pumps, co-generation)
  - ➔ Storage needs: allow for de-coupling of heat supply and electricity production (< 1 hour to a few hours)

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Solar domestic hot water systems

- DHW storages mature
- R&D issues
  - Stratification
  - Integration of PCM in the upper part (melting point at hot water temperature)
  - Integration of sorptive unit for providing loss free energy over a longer period (Uni Stuttgart)

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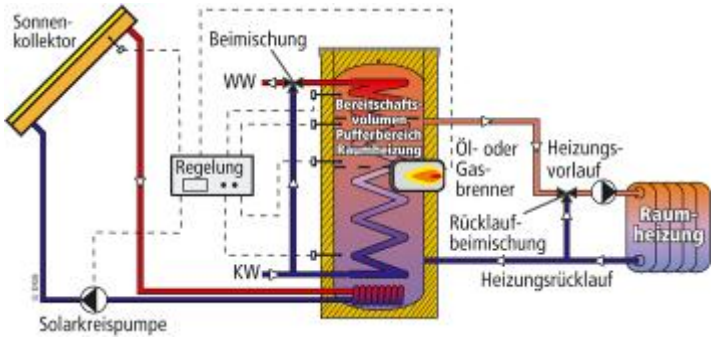
Solar combi-systems

- Established solution: buffer storage using water (e.g. 800 – 2000 litres for single family house)
- Ongoing developments
  - Cost reduction by using other geometry (non-cylindric) and low cost wall materials
  - More installation-friendly solutions: flexible construction to be assembled on-site
- Storage R&D
  - Other materials/concepts (thermo-chemical, chemical) for enhanced energy density



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Solar heating systems

- Long-term storage to save (part of) summer solar heat to heating season
- Today mainly feasible in combination with large centralized storage and district heating systems
  - New Task with in SHC under discussion: combination of solar thermal, seasonal storage with/without centralized heat pumps
- Also a number of installations in multi-family or even single-family houses exist
  - Storage very large and strongly affecting the architecture
  - Challenge extremely high for other materials/concepts due to low number of cycles (➔ only low cost materials/concepts economically acceptable)

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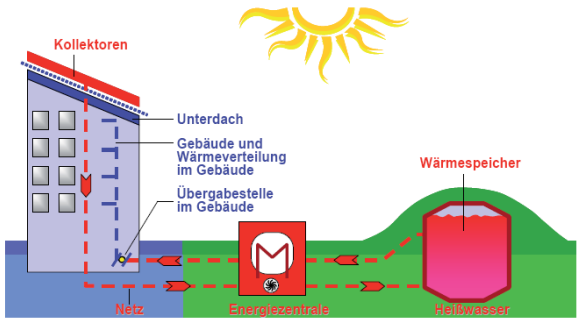
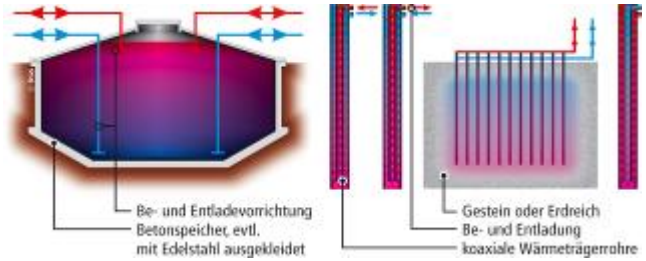
Large solar heating systems

- Different types of seasonal storage
  - Water
  - Ground
- Main R&D
  - Construction technology
  - Cost reduction





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Simulation study

Location: Freiburg/GE

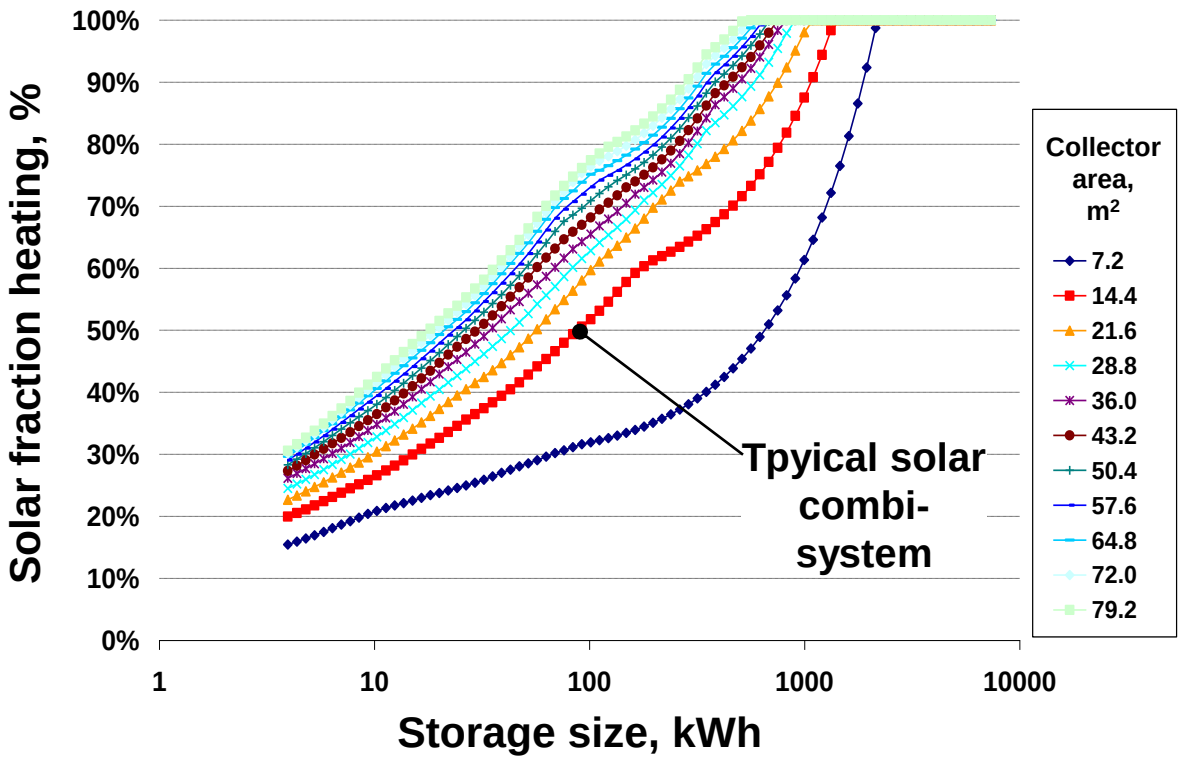
High energy standard (heating 20 kWh/m²a)

Low-T heating, 30°C

Evacuated tube collector

100 % solar fraction for heating achieved with:

- A_{coll} 28.8 m²
- Q_{st} 906 kWh



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Simulation study

Location: Freiburg/GE

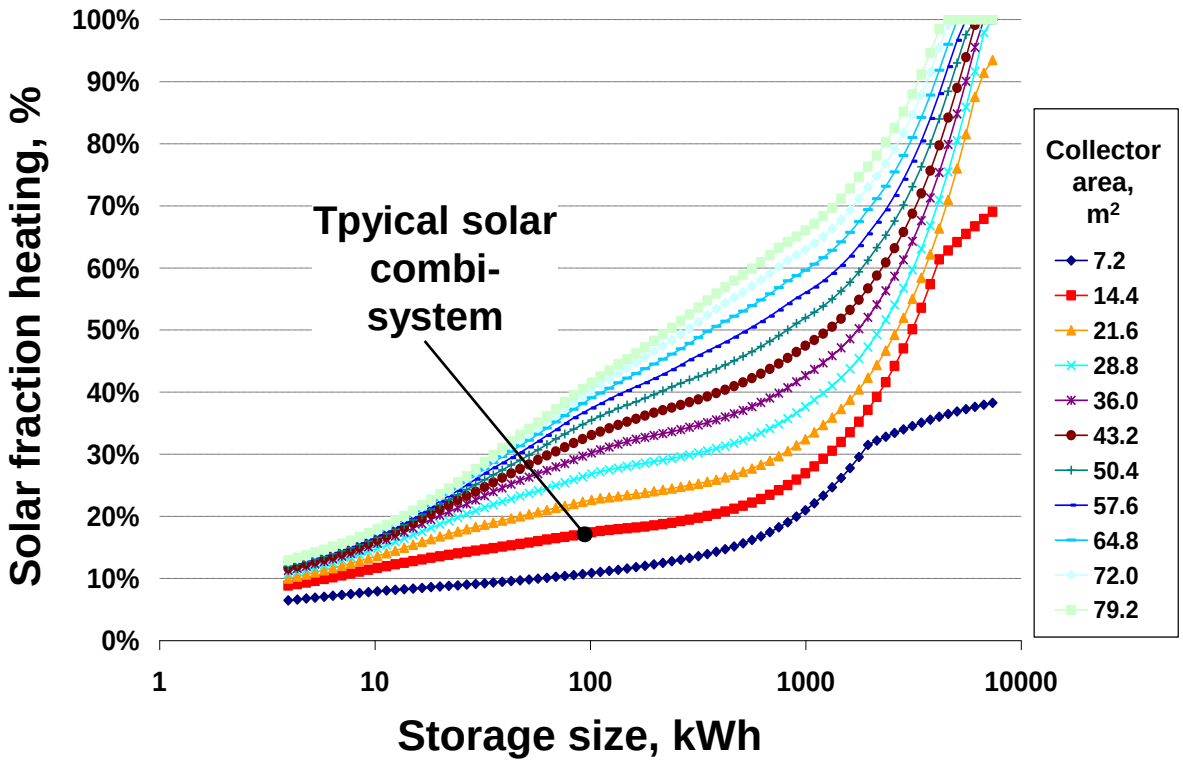
Medium energy standard (heating 60 kWh/m²a)

High-T heating, 50°C

Flat plate collector

100 % solar fraction for heating achieved with:

- A_{coll} 43.2 m²
- Q_{st} 6700 kWh



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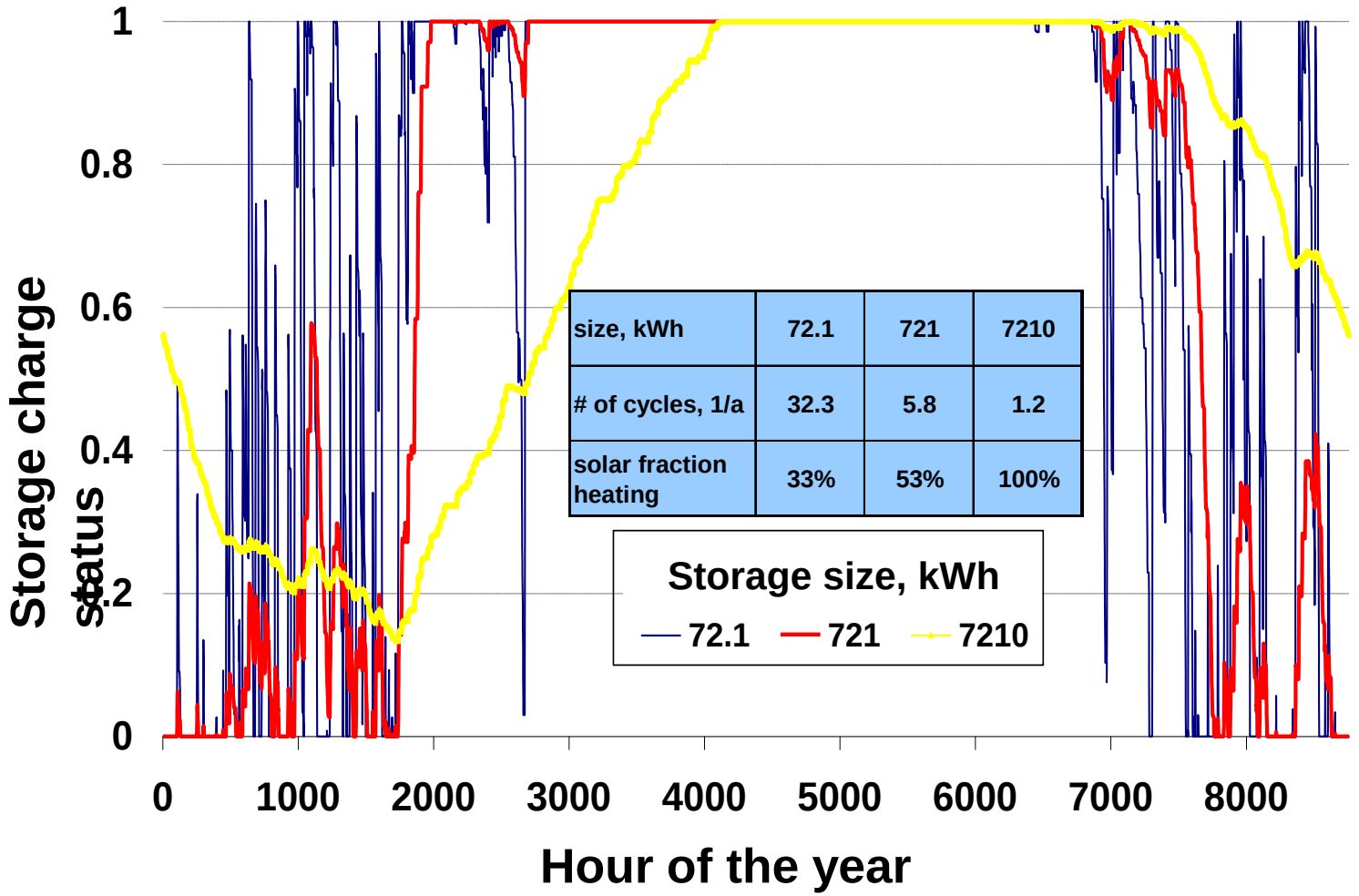
Storage sizes – annual time pattern of charge state



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Energy efficiency concepts

- Main goal: de-coupling of heat and electricity
- Heat pumps
  - Allow operation of heat pump following needs from energy supply ➔ increase flexibility for grid
  - Storage size from < 1h up to several hours
- Co-generation
  - De-couple electricity production and heat use
  - Optimize electricity production towards best feed-in conditions or in-house electricity use
  - Avoid wasting of co-generator's heat
  - Storage size from < 1 h up to several hours

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Summary

- Yes, energy storage is needed
- Cold storage is a key element to increase the use of renewable energies (solar energy) for air-conditioning and refrigeration as well as energy-efficient solutions
- PCM and chemicals promise advanced solutions
- Typical storage sizes up to 1 day capacity
- Various types of heat storage are used in combination with hot water and heating in buildings
- Main focus
  - Cost reduction of existing solutions
  - New materials/concepts mainly for medium size (days to weeks)

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