QAiST

Quality Assurance in Solar Heating and Cooling Technology

Latest developments of Solar Thermal Technology

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- Introduction
- Latest development related to key components
  - solar collectors
  - heat stores
- Latest development related to systems
- Conclusion

The 2030 solar thermal vision of the ESTTP

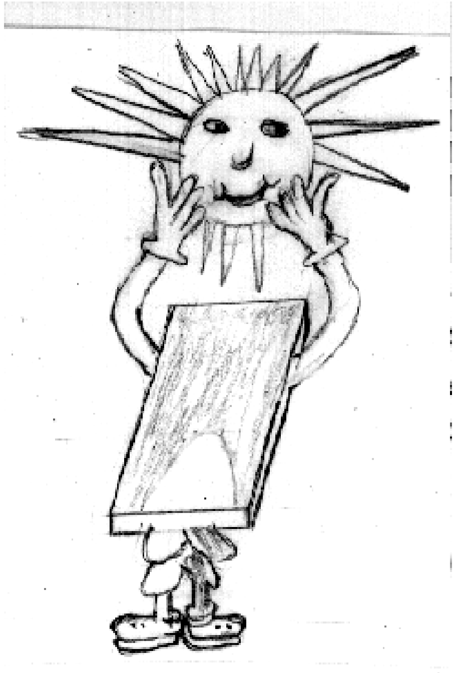
The heat and cold demand is covered by solar thermal energy to **100 % for new built houses** and to at least **50 % for the existing building stock**. For industry and agricultural applications a **significant share of heat below 250 °C** is delivered by solar thermal energy.

→ Overall goal: To cover 50% of the low temperature needs up to 250°C with solar thermal energy

What does this mean for solar thermal technology?

Ongoing research and development is required!

Examples of latest R&D developments related to solar collectors



Polysol - Development of an all polymeric collector

Injection machine

Key features:

- Significant weight and cost reduction
- Use of recycled polymeric materials
- Made by extrusion
- Overheating protection by temperature dependent emissivity
- Pressure resistant up to 4 bar

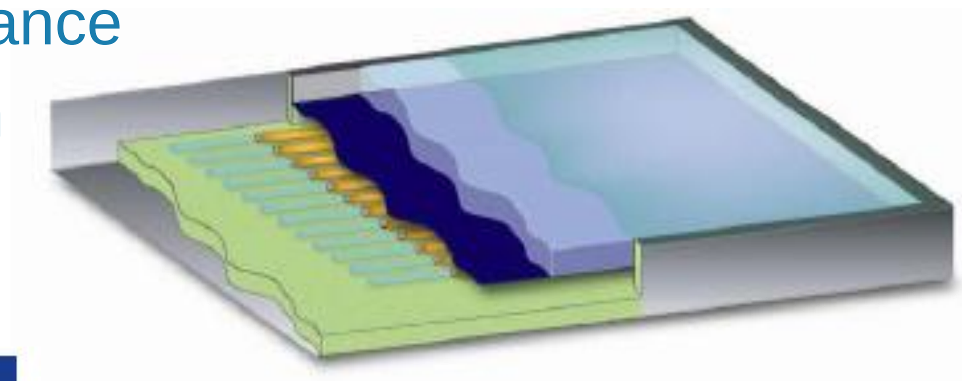
PVD chamber

POLYSOL a consortium of 10 partners from 5 different European countries

Gas filled flat plate solar collector

Key features:

- Filling gas e.g. Xenon, Argon, Krypton
- Higher thermal performance
- Thinner collector design and reduced weight



CHALMERS

Chalmers University of Technology
Gothenburg, Sweden

Facade collector based on vacuum tubes

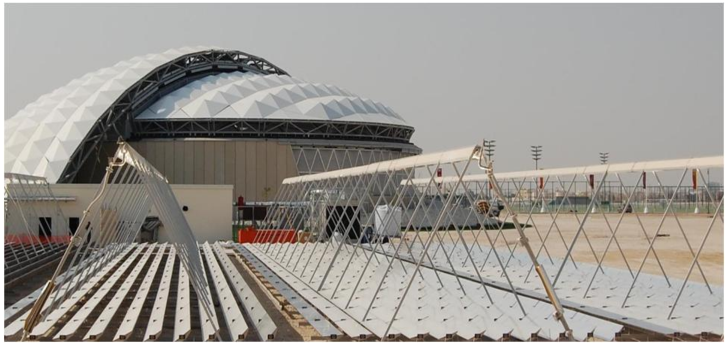
- Combination of glass façade and evacuated tubular collector
- CPC mirror is perforated to allow light to enter the building

Source: Ritter Energie- und Umwelttechnik, University of Stuttgart

Industrial Solar Fresnel Collector Field

Key features:

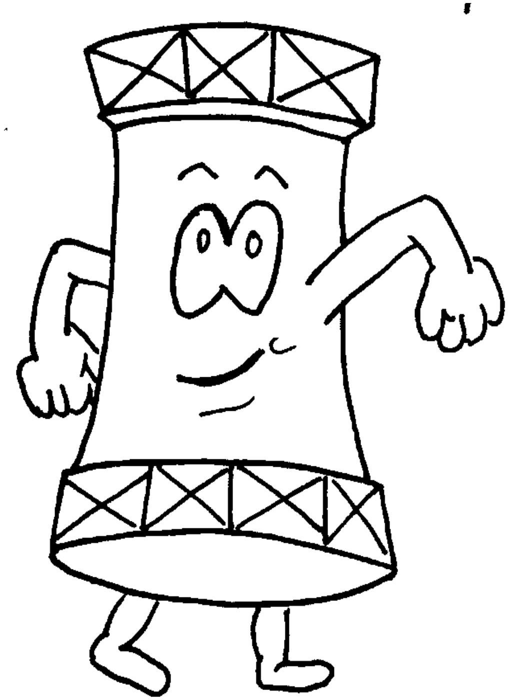
- 4 collector strings
  with 16 modules each
- Gross area approx. 2100 m²
- Total aperture area 1408 m²
- Pressurised water circuit at 16 bar
- provided temperatures: 200 °C
- used to drive an absorption chiller



solar cooling of a football stadium, Doha, Qatar

Source: INDUSTRIAL SOLAR thermal solutions Freiburg, Germany

Examples of latest R&D developments related to heat stores



Water stores

- Achievement of large volumes by cascading

Disadvantages:

- Large space requirement
- Great effort for installation and control
- High thermal losses due to large surface

Large water stores

Key features:

- Large stainless steel store (pressurised)
- New buildings: installation during construction phase
- Existing buildings: Welding at the place of installation

17,5 m^3 store; source: http://www.jenni.ch/

Cylindrical polymeric stores

Key features:

- cylindrical polymeric store made from fibreglass-reinforced plastic
- prefabricated components, laminating at place of installation
- volume: 1 – 100 m³
- with this flexibility only available as unpressurised store

Polymeric store of Fa. Haase; source: http://www.ichbin2.de/waermespeicher.html

Cubical polymeric water store

Key features:

- Optimal use of space due to cubical shape
- Steel frame with polymeric panels
- Construction and sealing on-site
- Individual sizing to fit the room
- unpressurised

Pressurised polymeric water stores

Arbeitsgemeinschaft Druckspeicher:

Key features:

- First pressurised cylindrical polymeric store made from fibreglass-reinforced plastic
- Low thermal conductivity
- Corrosion-free
- Low weight
- Stratified charge and discharge device

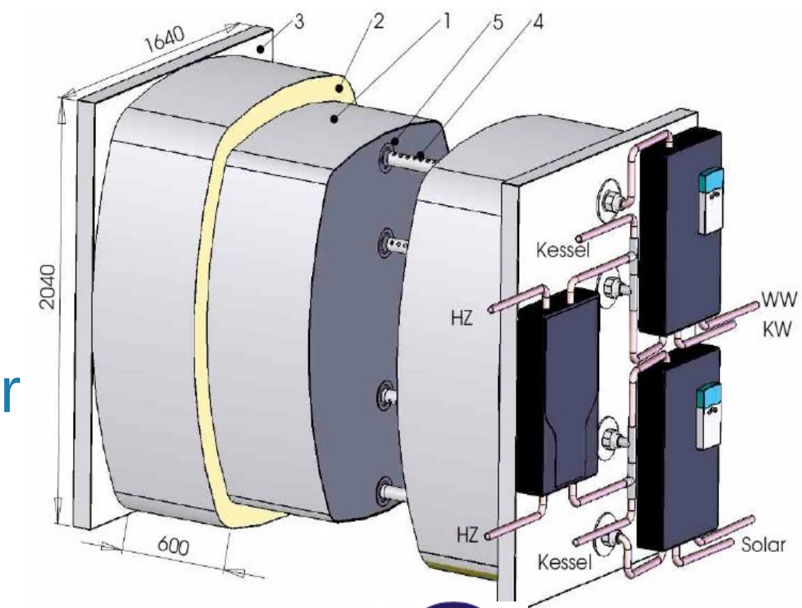
prototype with 4 m³

source: http://www.energie-depot.com/bildergalerie.10.html

ModSto – Modular hot water store

Key features:

- Reduced space requirements compared to typical cylindrical hot water stores (PP)
- Pressure resistant up to 2,5 bar
- Module volume 1.3 m³
- Total volume up to 10 m³
- Very low heat losses
- Quick and easy installation



Source: Consolar

ITW, University of Stuttgart

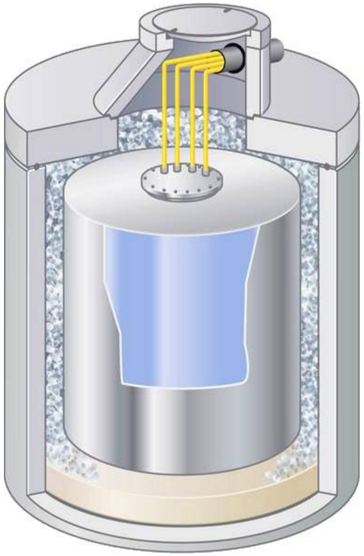
Underground stores

Key features:

- Large volume achievable independent of building size
- Installation also possible in building stock
- Unpressurised stores up to 7 m³
- Pressurised stores up to 11 m³
- Significant costs for ground works

In development:

- Diffusion resistant foil bag instead of a steel store



source: Mall Umweltsysteme

Heat losses of water stores

Major disadvantage of storage of sensible heat is heat loss.

Counter action:

- Thermal insulation with low thermal conductivity
- Good fit of thermal insulation
- Avoiding thermal bridges
- Prevention of convection inside the storage connections

Volume	Heat loss rate	Annual heat loss of the store	
300 l	2 – 2,7 W/K	ca. 500 kWh/a	hot water system
1.000 l	3 – 4 W/K	ca. 1000 kWh/a	combisystem
10.000 l	9 – 10 W/K	---	

Vacuum super insulated water store

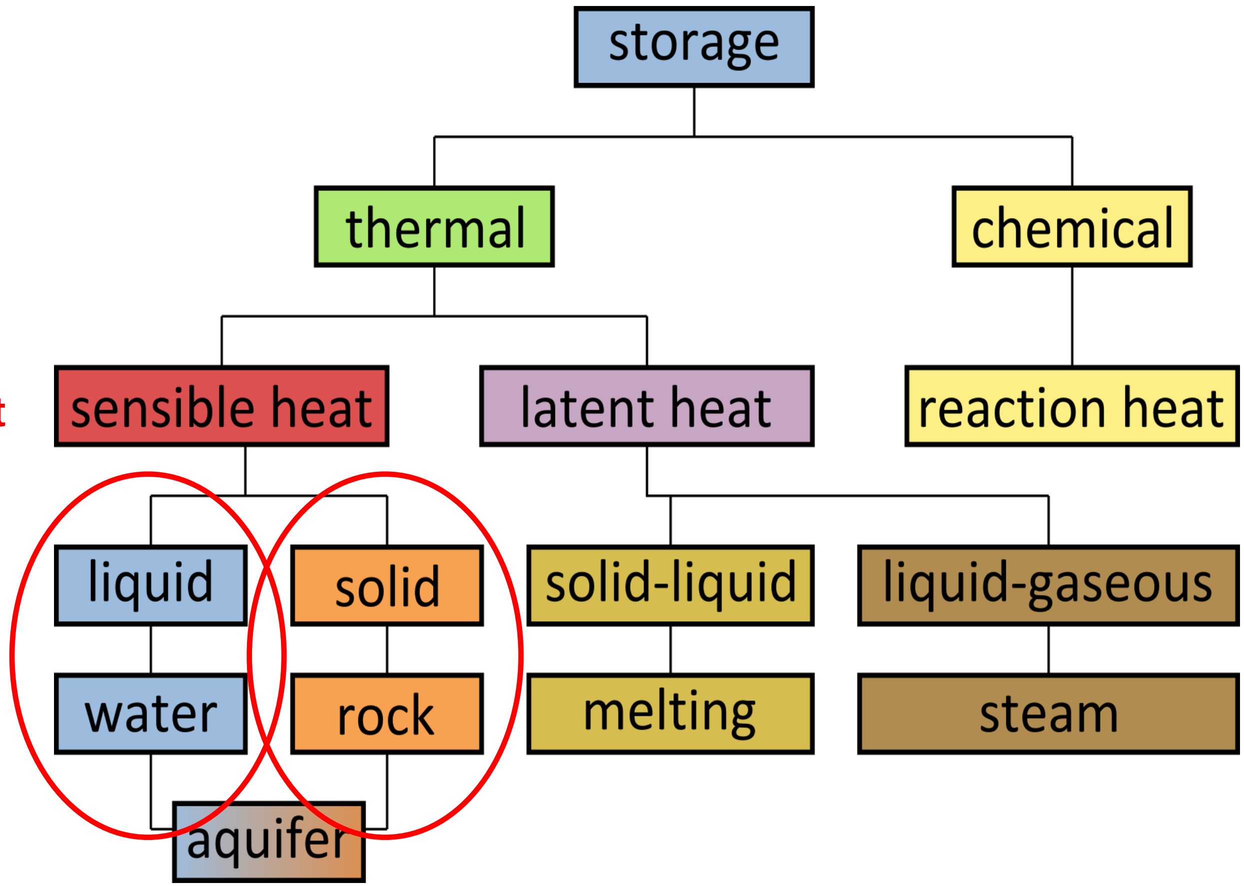
Key features:

- Extremely low heat losses
  Heat loss rate for a 16 m3 store: 1.98 W/K
  (typical value for a “standard” 250 l store)
- Perlite powder used as filling material
  - low costs 50 €/m³
  - low density 30-100 kg/m³
  - small pores 10-100 µm
  - high porosity 75-97 %

Source: ZAE Bayern, Germany

ZAE BAYERN

Mechanisms of heat storage



- **Storage of sensible heat**

- **Water store**
  - space heating
  - climatisation

- **Solid store material**
  - underground storage
  - ceramic material for high temperature processes

Underground heat storage

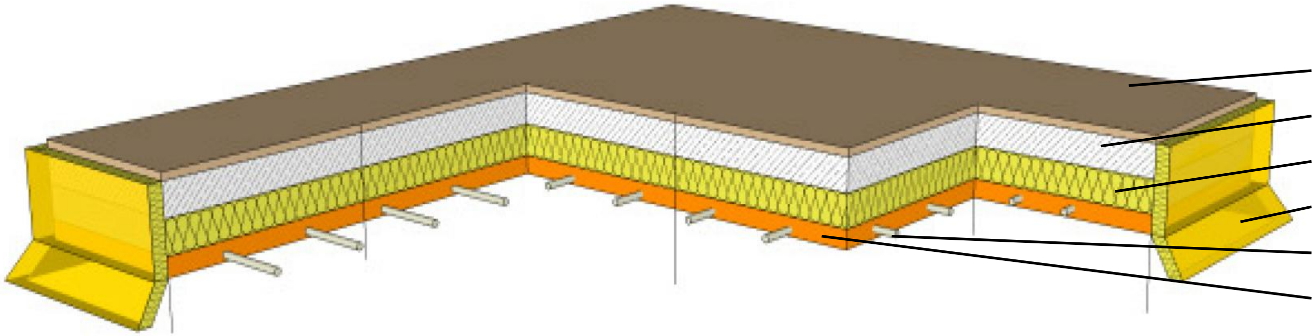
Investigation of University of Innsbruck and Passive House Institute Darmstadt on a new concept to use solar and heat pump to supply heat to passive houses.

Key features:

- Single family home (2 Persons)
- energetic reference area 152 m^2
- Heat demand 15 $kWh/(m^2\ a)$
- Solar system: 10 m^2, 750 l
- Brine/water-HP 4,8 kW

source: Passivhaus Institut

Underground heat storage



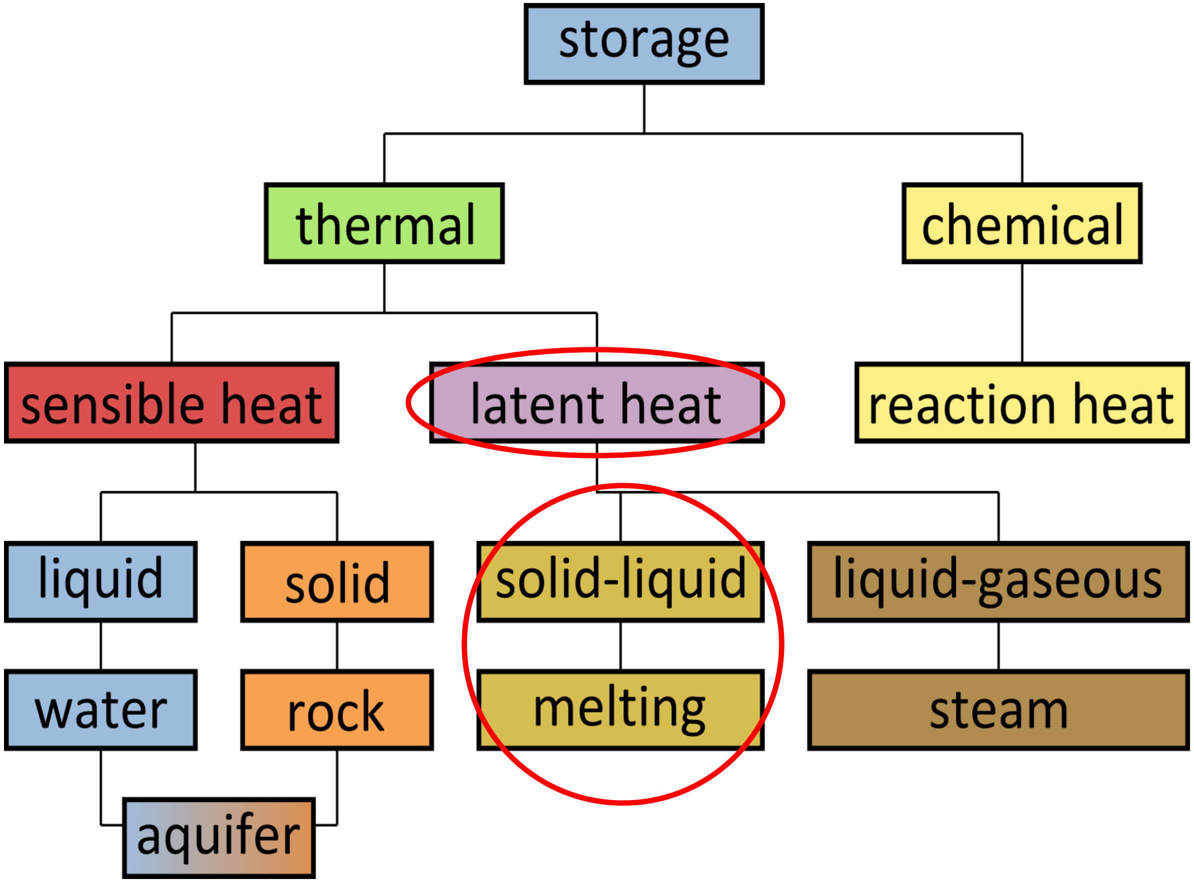
Ground-coupled heat exchanger: 4 x 75 m PE (20 x 2 mm) = 3 m/m² below base plate inside the clean layer

Application in single family homes:

- High technical effort for ground activation
- Low energy efficiency
- High thermal losses

Mechanisms of heat storage

- **Latent heat store**
  - **refrigeration and climatisation (restricted)**
  - **Additional heat store suitable for different renewable energy sources**



Mechanisms of latent heat storage

Advantages:

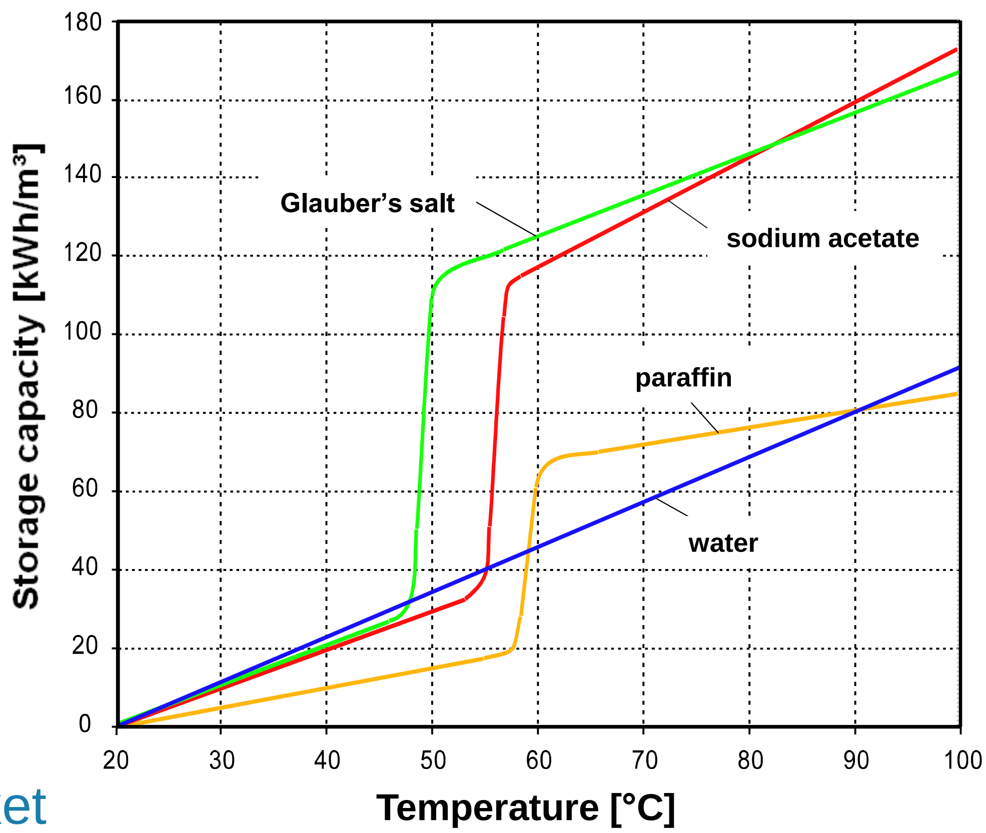
- High energy density at the phase change temperature

Disadvantages:

- Relatively high material costs
- Low thermal conductivity
- Large effort for heat transfer

Field of operation:

- Single PCM store
- Combined with water store
- Very few suppliers in the market



Latent heat storage in ice stores

Key features:

- Very large heat of fusion
- Low material costs

Field of operation:

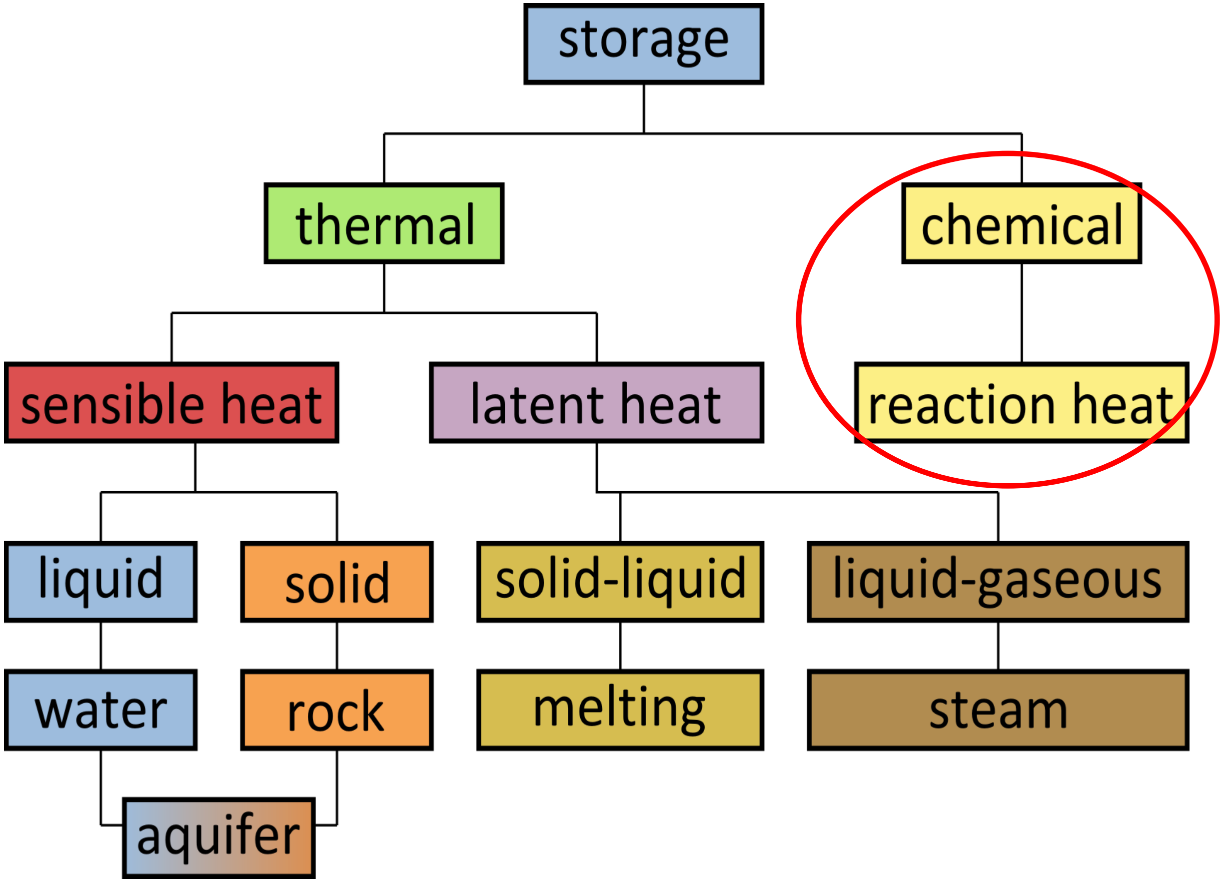
- In combination with heat pump systems
- For „cold storage“ in solar thermal cooling systems

Source: ITW, Germany itw

Mechanisms of heat storage

Thermo-chemical heat store

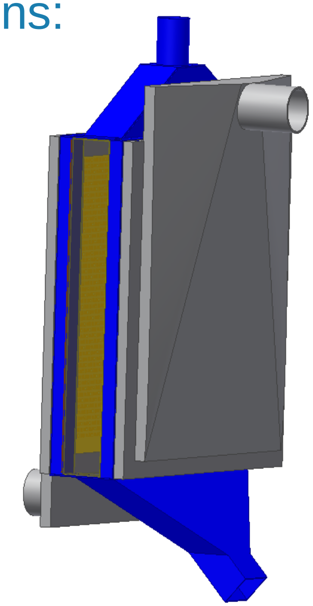
- first developments in the field of adsorptions-processes
- first approaches in the field of chemical reactions

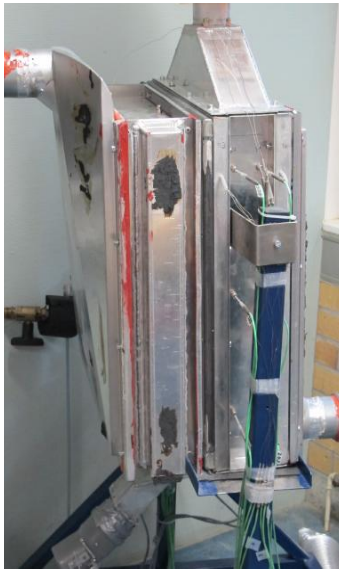


Development of thermo-chemical heat stores

Chemical heat store for low temperature applications:

- Open adsorption/hydration system using ambient air or exhaust air
- Salt in combination with an active / passive porous matrix
- Most promising composite material:
  - $CaCl_2$ on passive matrix
  - $MgSO_4$ on active matrix
- External cross-flow reactor with structural integrated heat-exchangers
- High regeneration temperatures (120-180 °C) required
- Experimentally reached storage density: 230 kWh/m³
- Loss less heat storage





advanced reactor for a thermo-chemical heat store

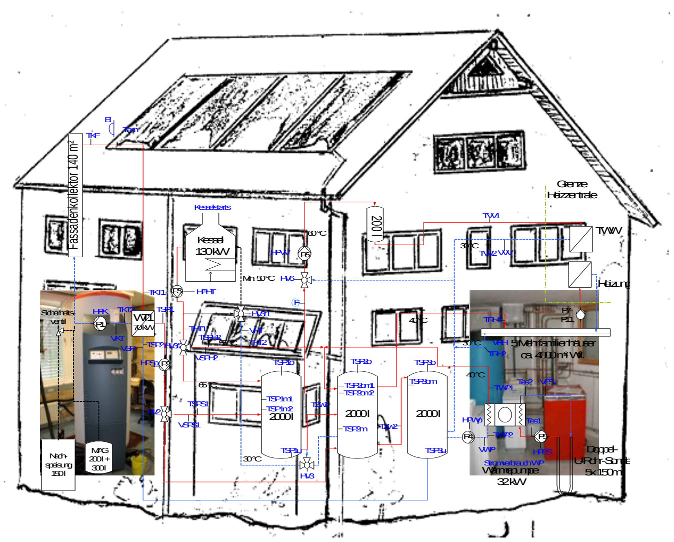
Source: ITW, Germany

Comparison of heat store mechanisms

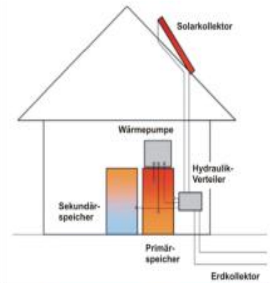
	Energy density	Factor
Ground soil*	ca. 35 kWh/m³	0,5
Water*	60 kWh/m³	1
Latent	50 - 120 kWh/m³	1 – 2
Adsorption	120 - 180 kWh/m³	2 – 3
Reaction	200 - 600 kWh/m³	4 – 10

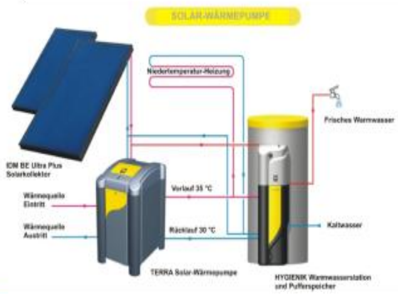
* at $\Delta T = 50$ K

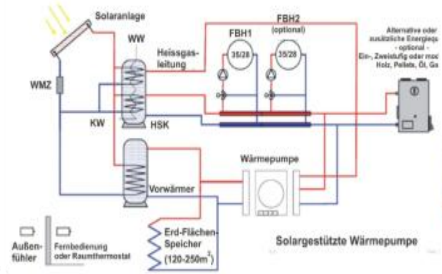
Examples of latest R&D developments related to system technology

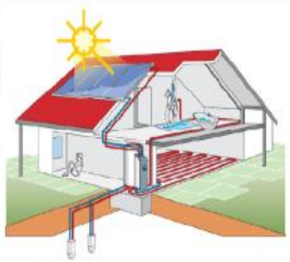


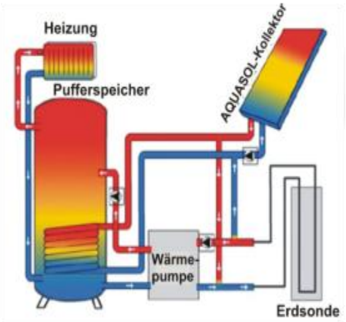
Combined solar thermal and heat pump systems

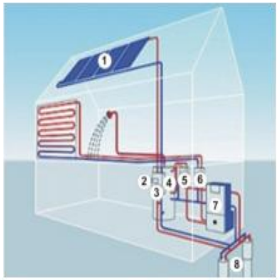


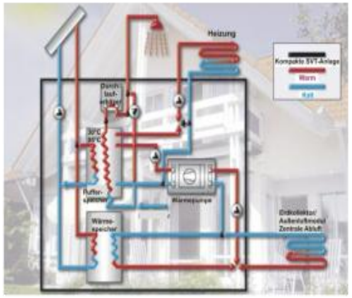


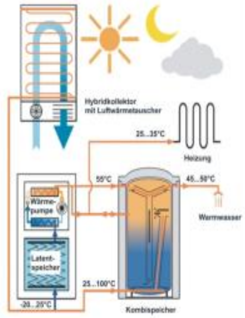


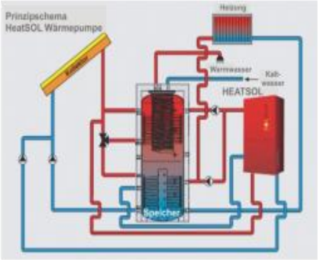


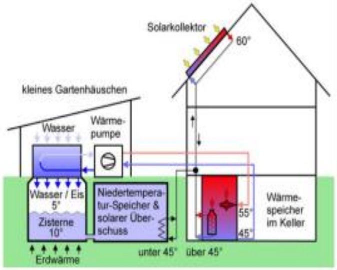




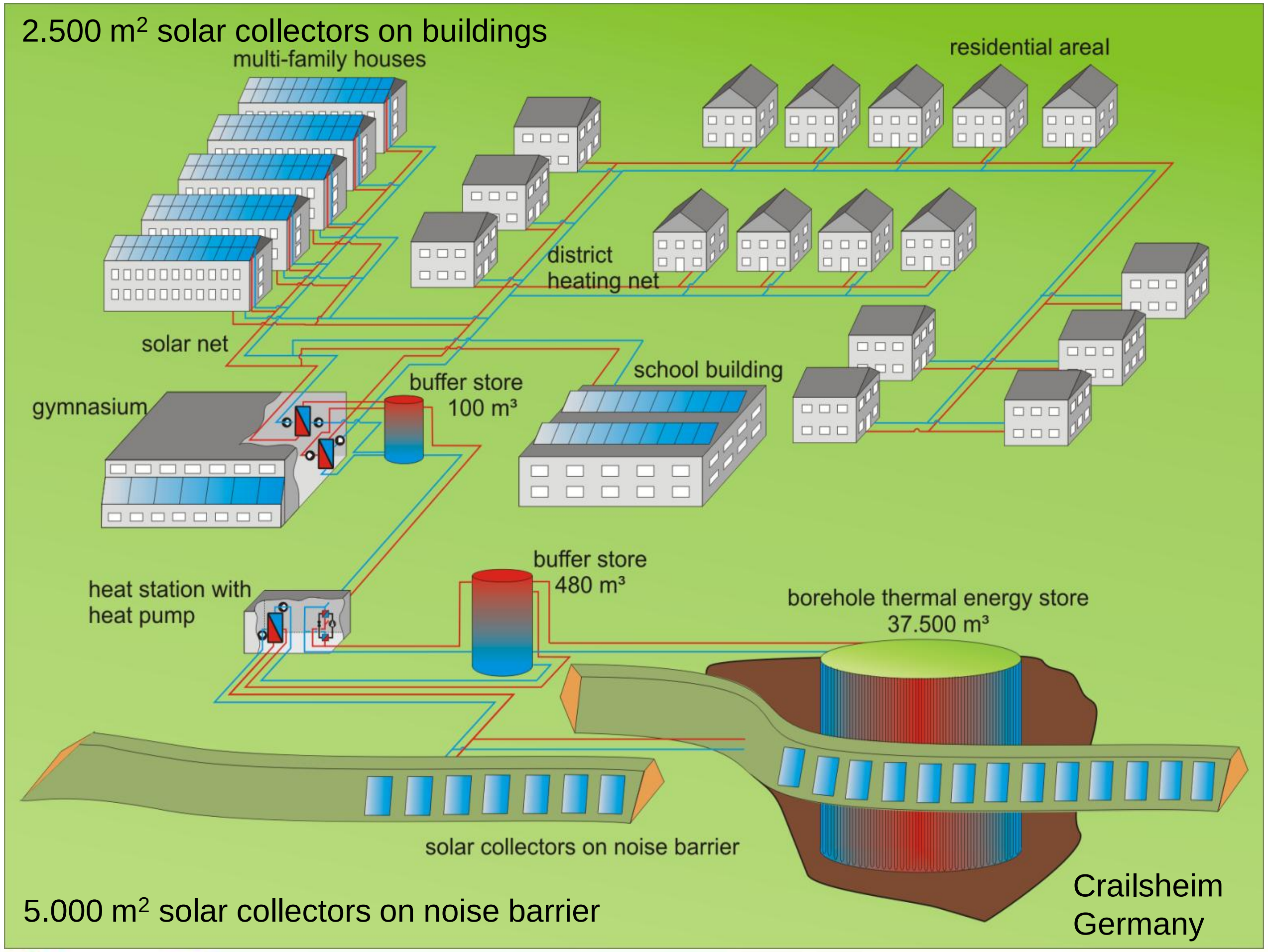








Solar district heating with seasonal heat store

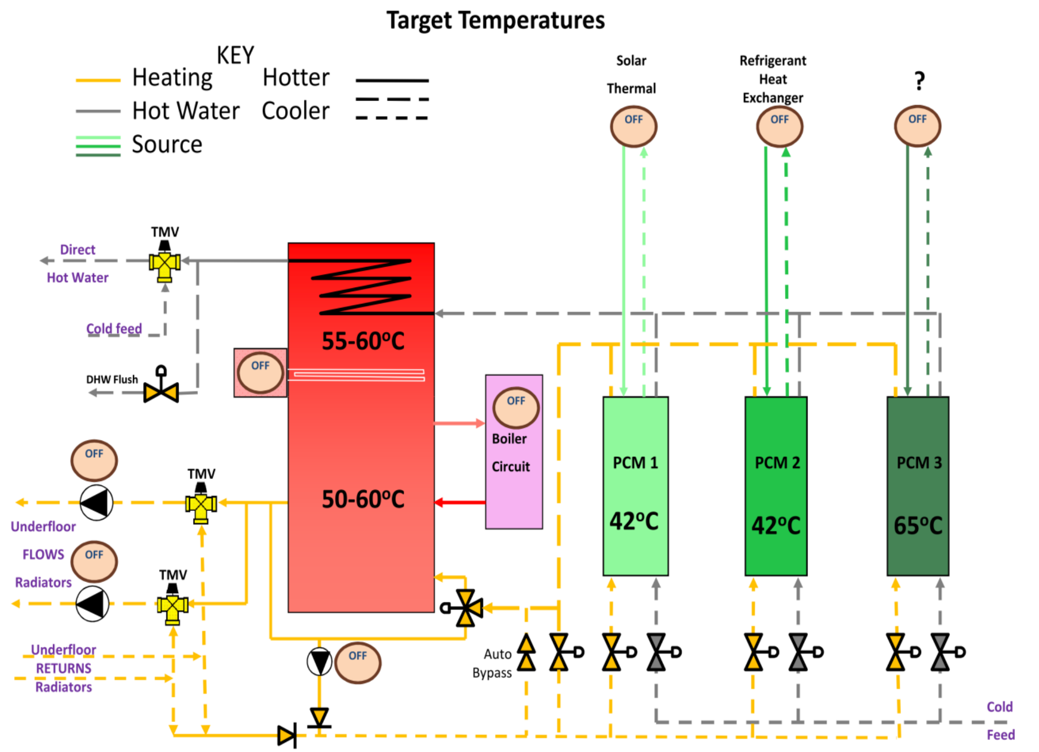


Source:
ITW, Germany

SmartHeat – intelligent modular SH & DHW

Key features:

- modular system topology
- effective integration and use of renewable energy sources
- Very applicable for retro-fitting
- Extendible by adding heat sources
- Reduced space requirements due to use of cubical PCM stores



Source: SmartHeat itw

Conclusion

- Ongoing research and development is required to achieve the goals of ESTTP
- Besides improvements in collector design and new system topologies efficient heat storage is most sufficient.
- In the present market almost exclusively water stores are the mature technology but still have further potential for optimisation:
  - Modular concepts to achieve larger volumes
  - Easy installation into building stock
  - Underground storage
  - Improved thermal insulation (vacuum-insulation)
- Thermal activation of the soil or building components has low potential for single family homes.

Conclusion

- Beginning activity in the field of latent heat storage (PCM)
- Ice stores are used in combination with heat pumps and the field of refrigeration and climatisation
- Thermo-chemical energy storage is promising but technically extensive
  - Loss-less long-term heat storage
  - High energy density of the store
  - Increasing national and international research activity
- Very large systems for district heating and seasonal storage as well as small systems with a high grade of flexibility due to modular system topology are being investigated.
- More intelligent controllers are being developed to guarantee an optimised use of several renewable energy sources.

Thank you for your attention!