Introduction to latent heat thermal energy storage

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ORC-PLUS workshop

Fraunhofer Institute für Solare Energiesysteme, ISE

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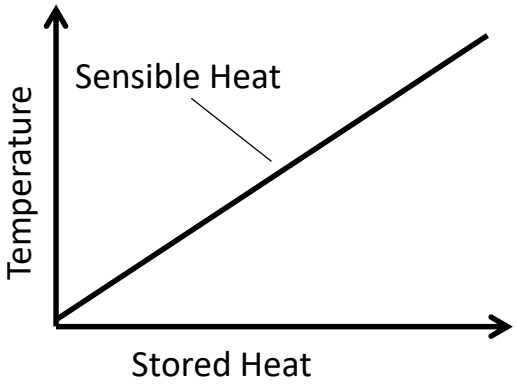
Agenda

- Overview on storage technologies
  - Priciples/Methods
  - Materials
- Latent heat storage technologies
  - Materials
  - Encapsulation
  - Examples for Latent Heat Storage Systems

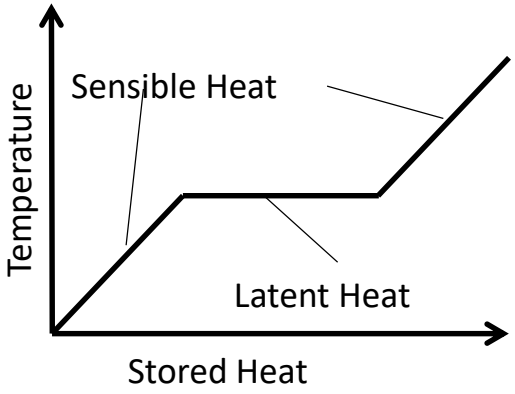
Thermal Storage Methods

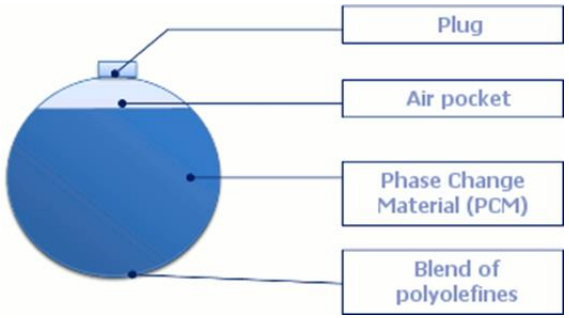
Sensible Heat Storage



Source: LSI

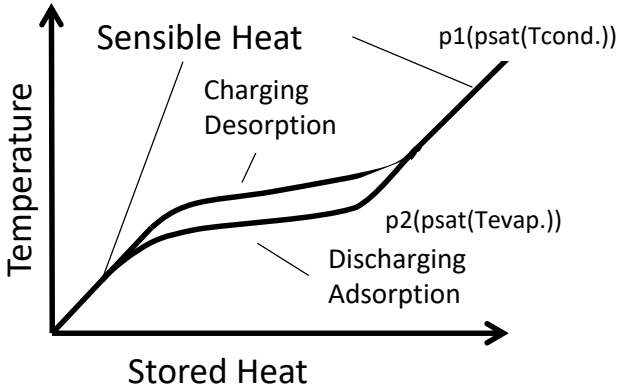
Latent Heat Storage

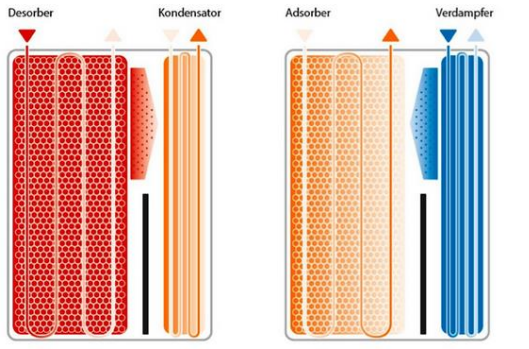




Source: Cristopia

Thermo-Chemical Heat Storage & Sorption Storages





Source: Sortech

TRL 7-9 **Energy Density / Complexity** **TRL 3 – 5/6**

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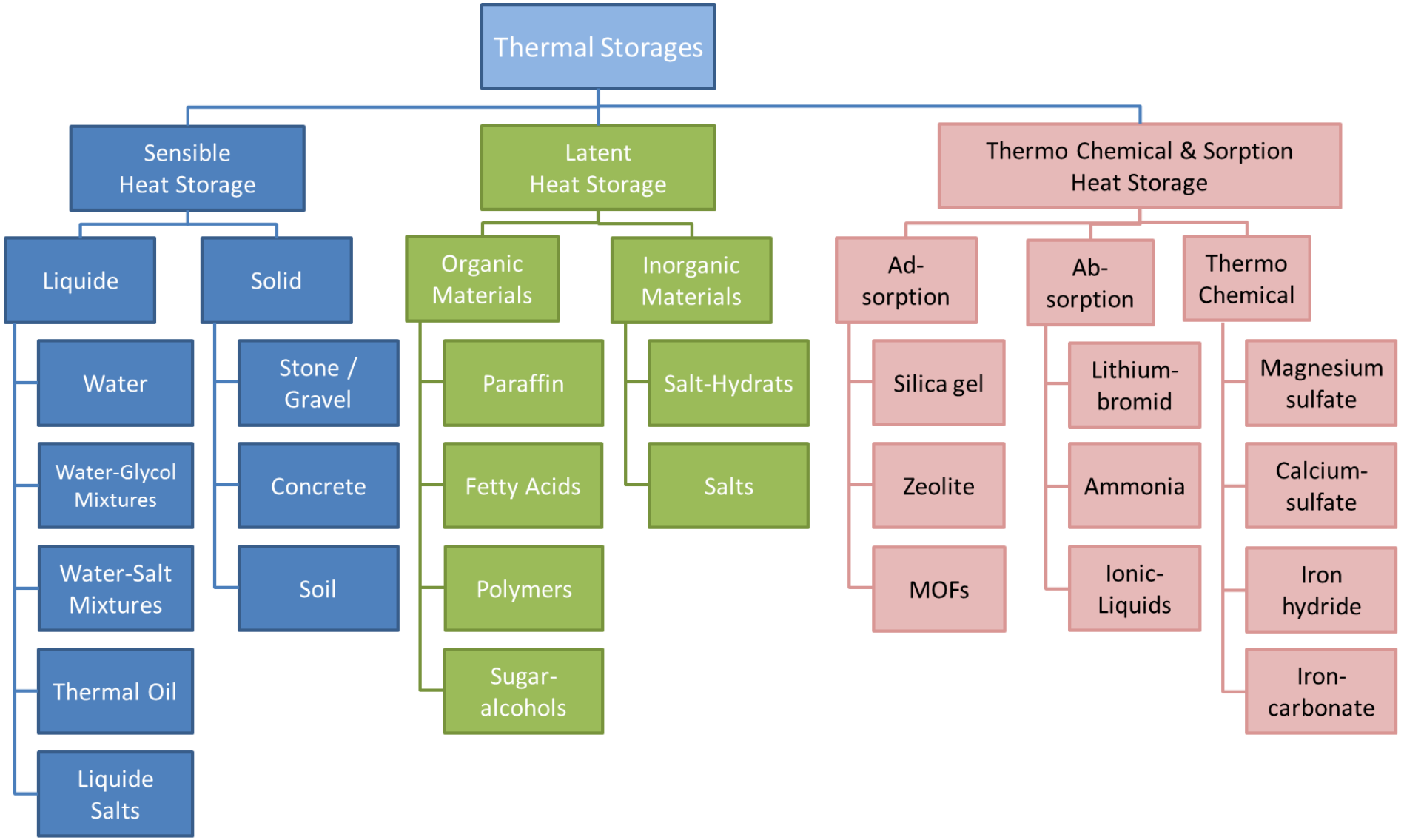

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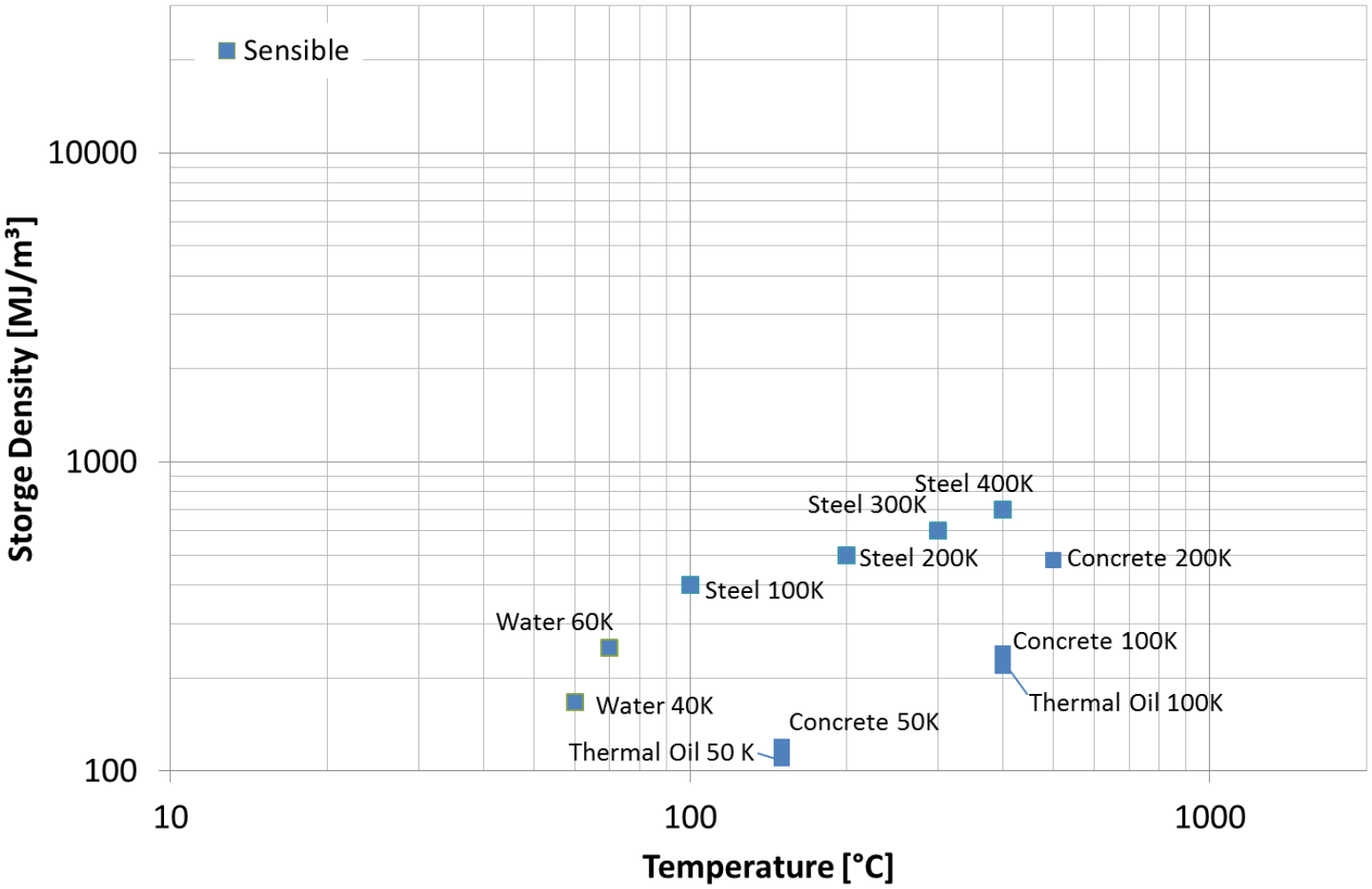
Storage Densities



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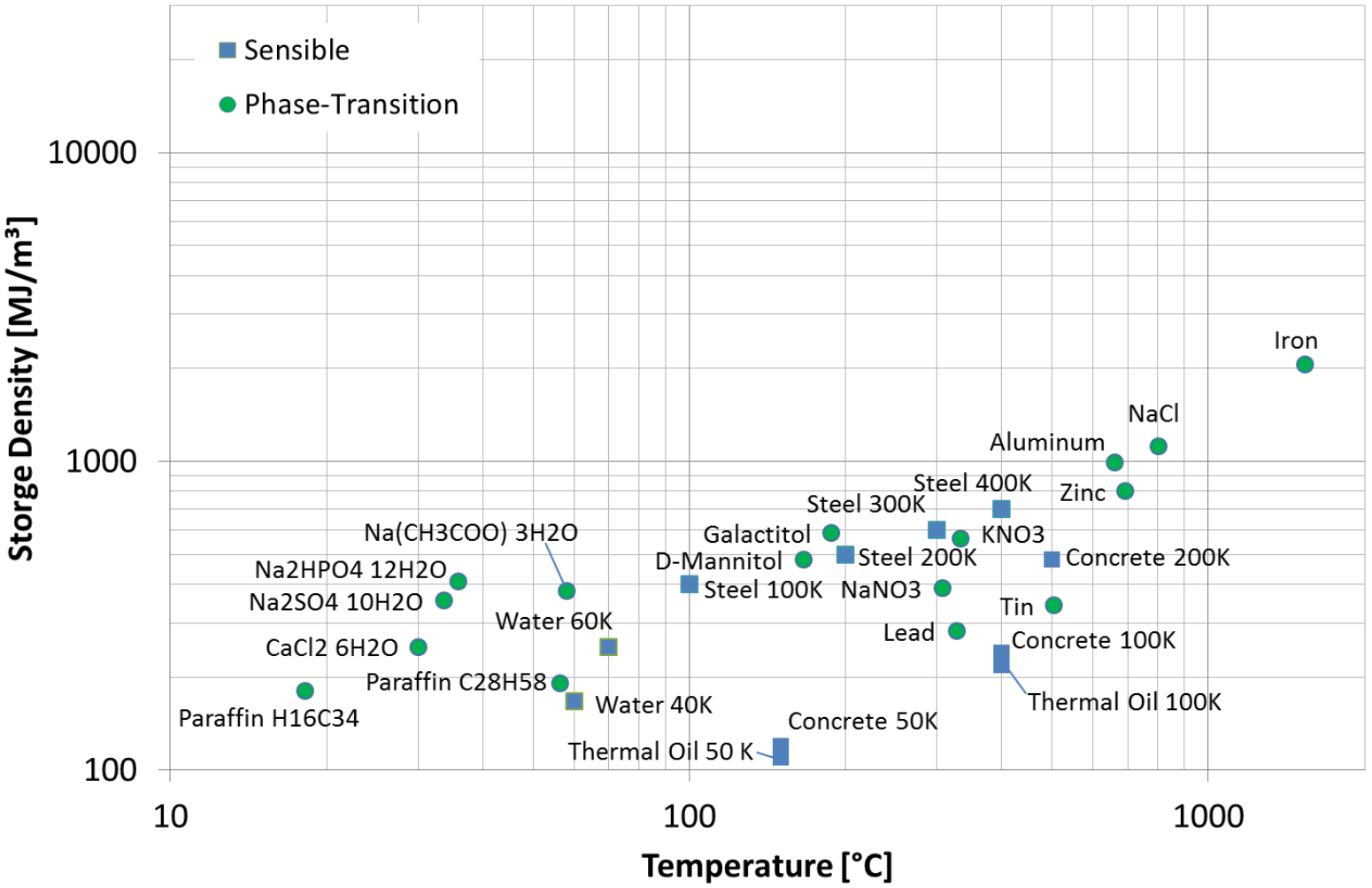
Storage Densities



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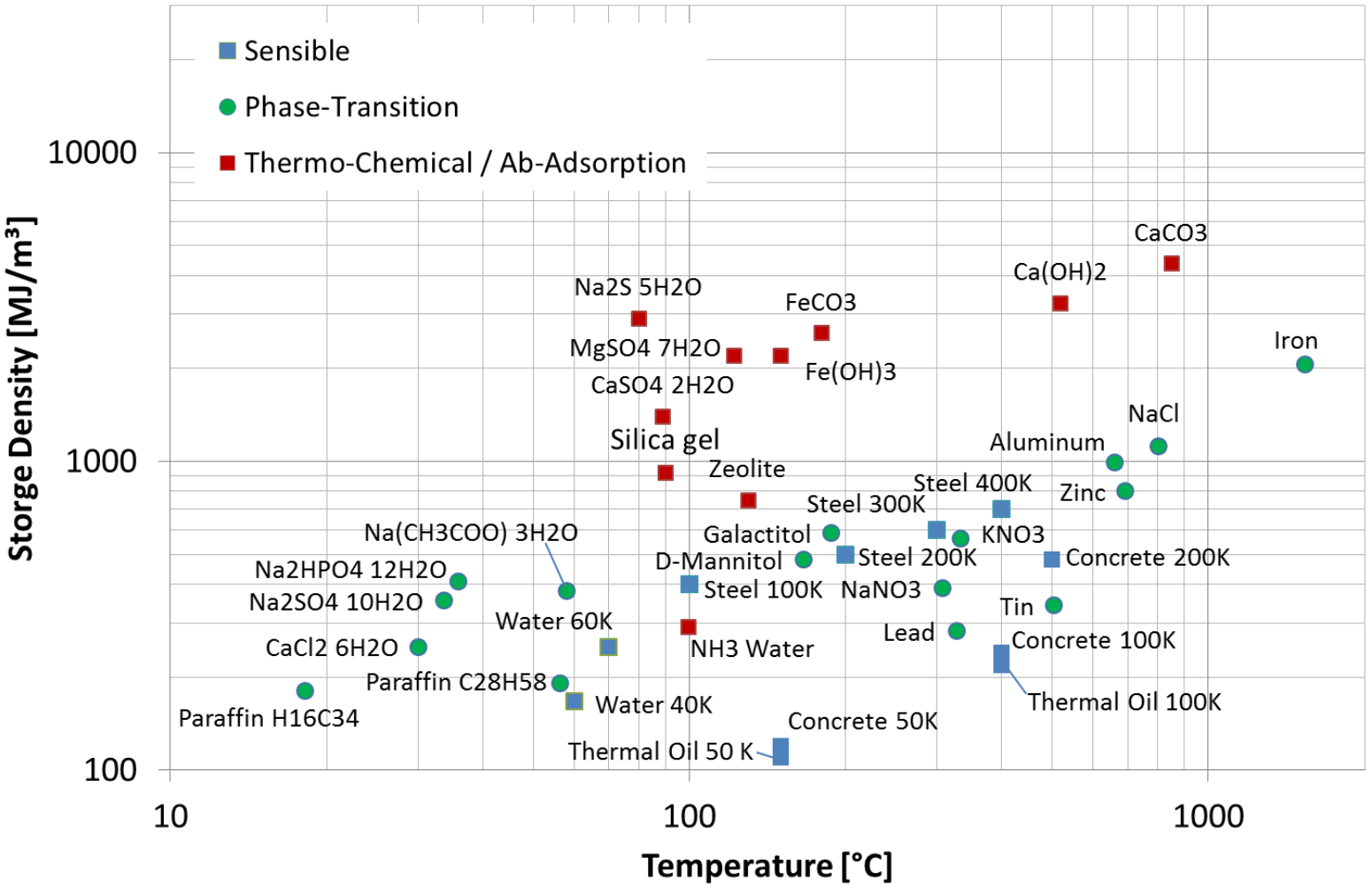
Storage Densities



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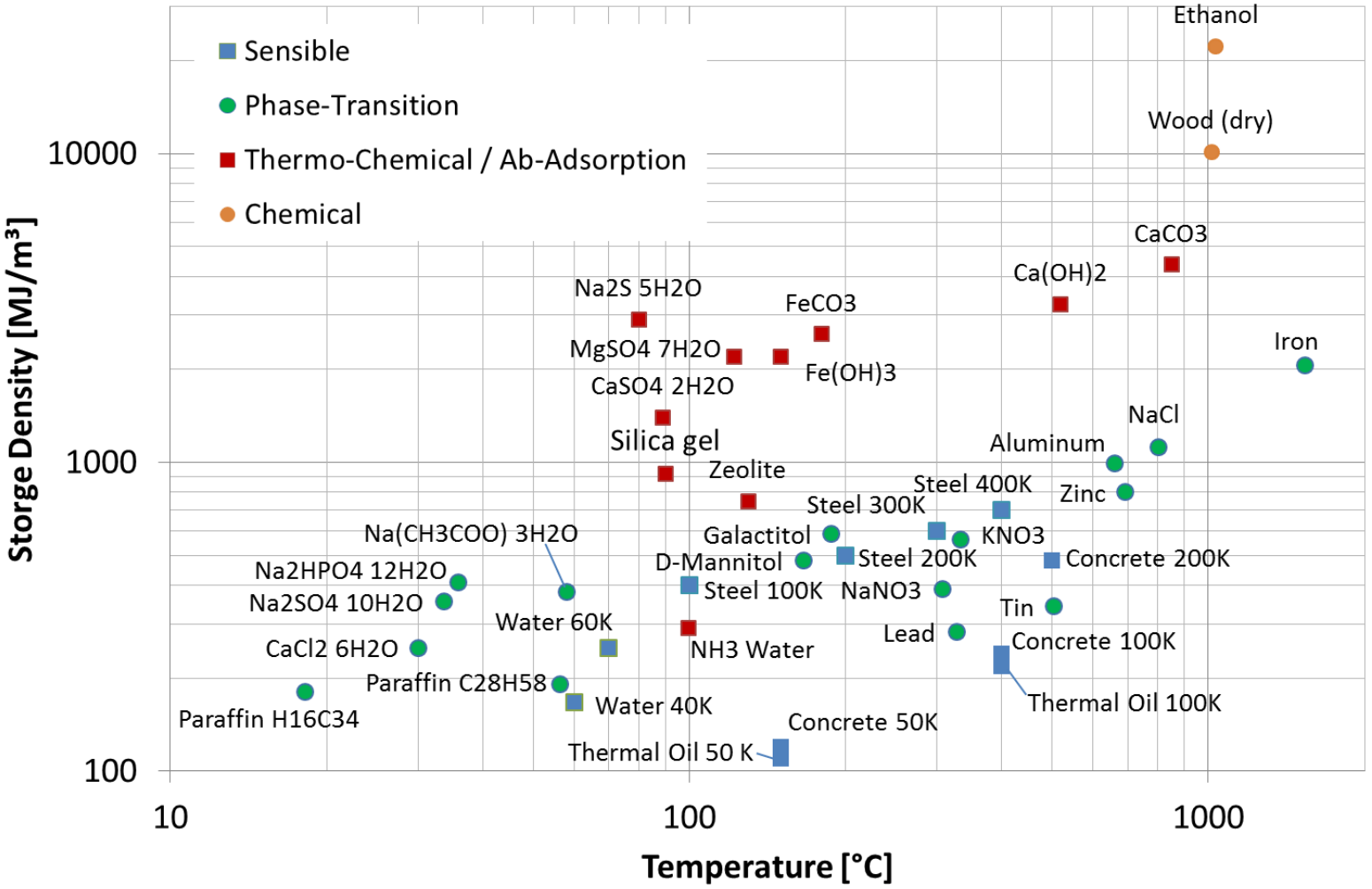
Storage Densities



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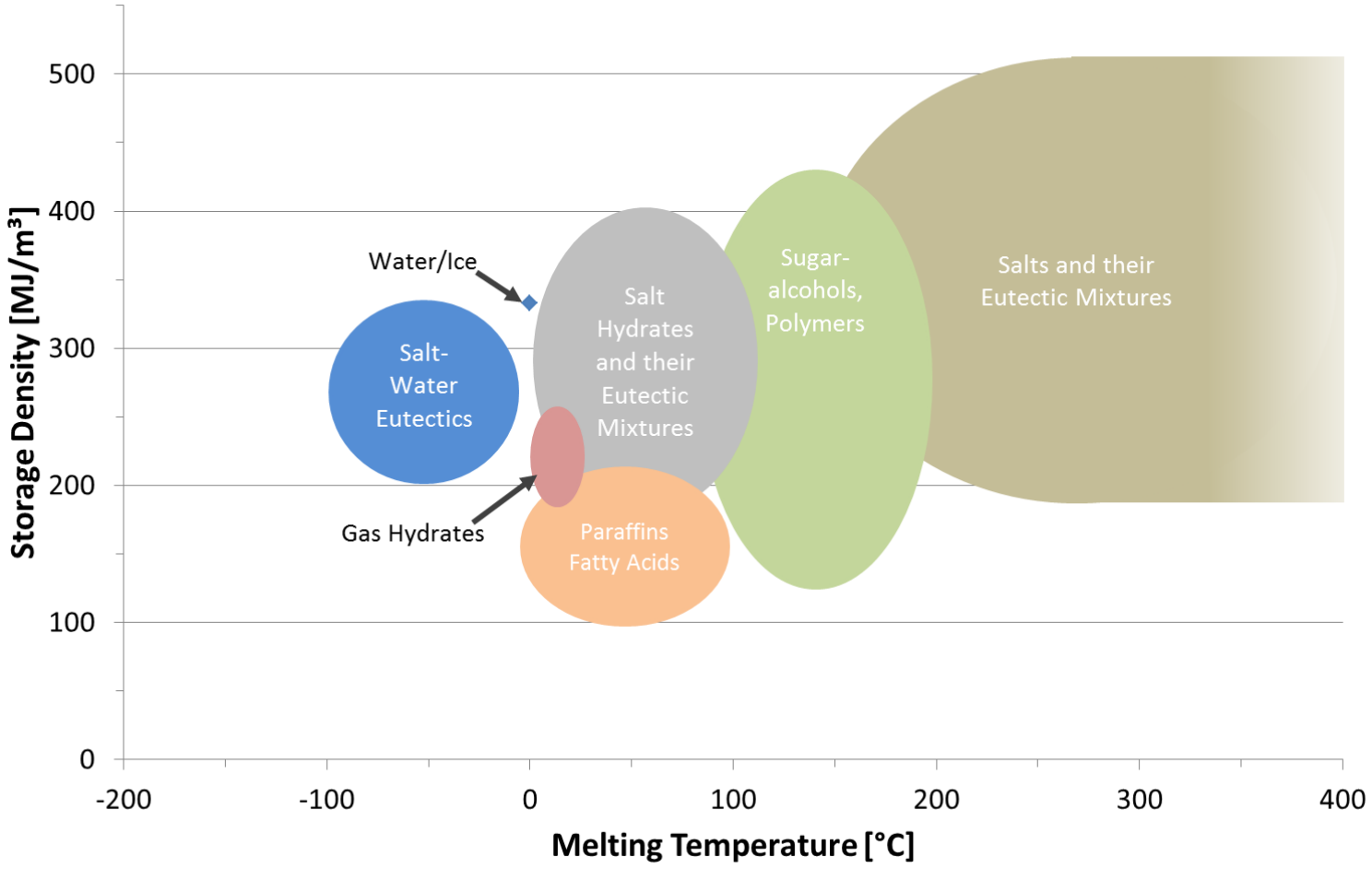
Storage Densities

Phase Change Materials Classes



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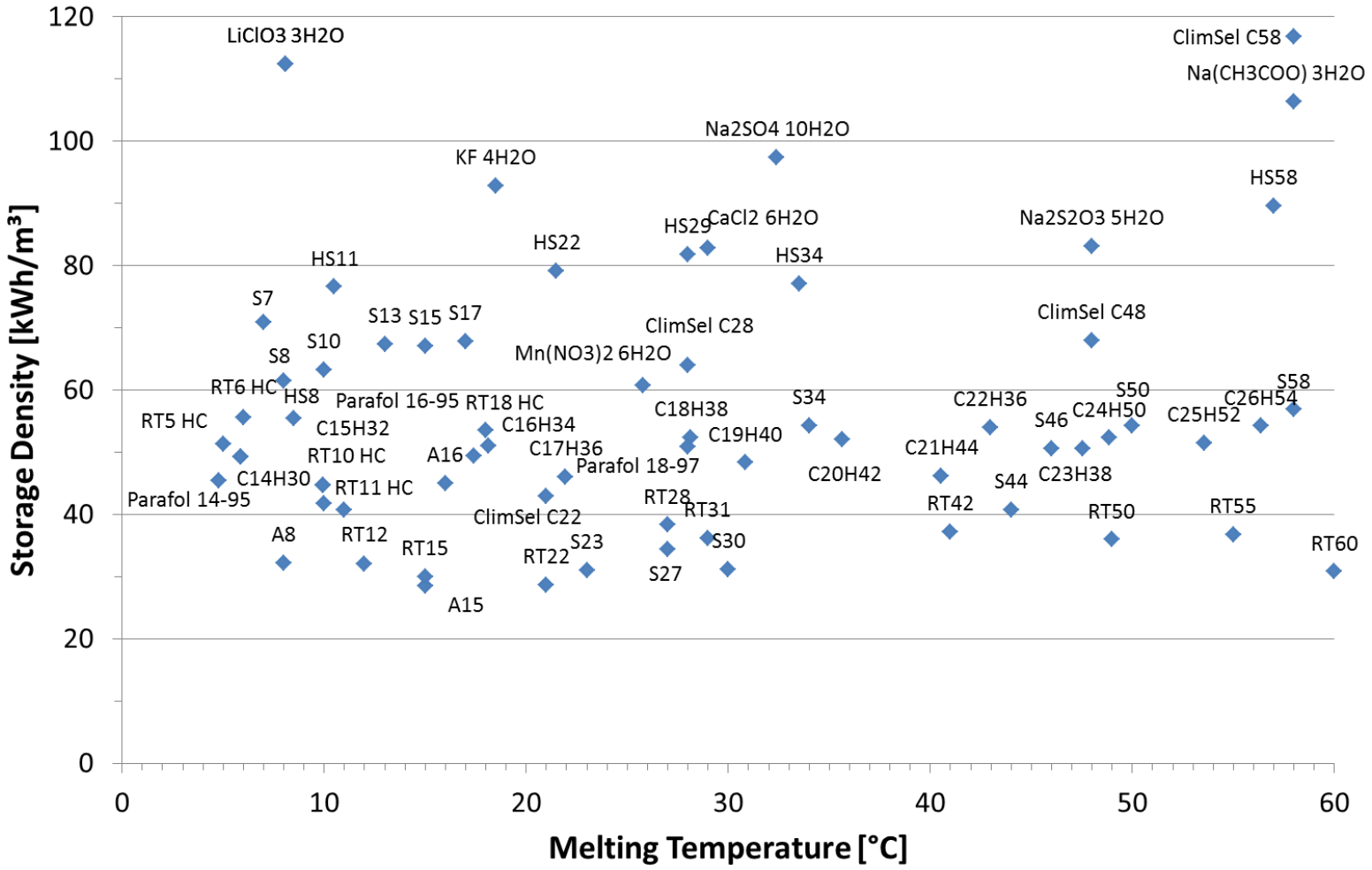
Commercial available PCM

Temperature range 0 – 60°C



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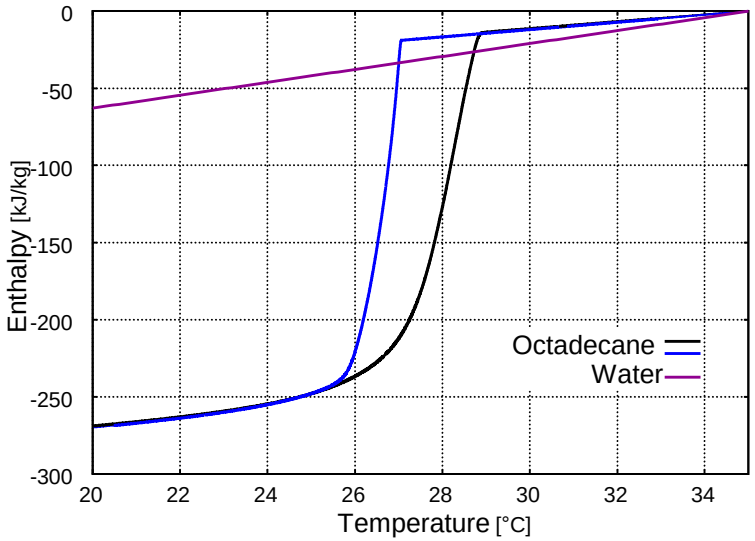
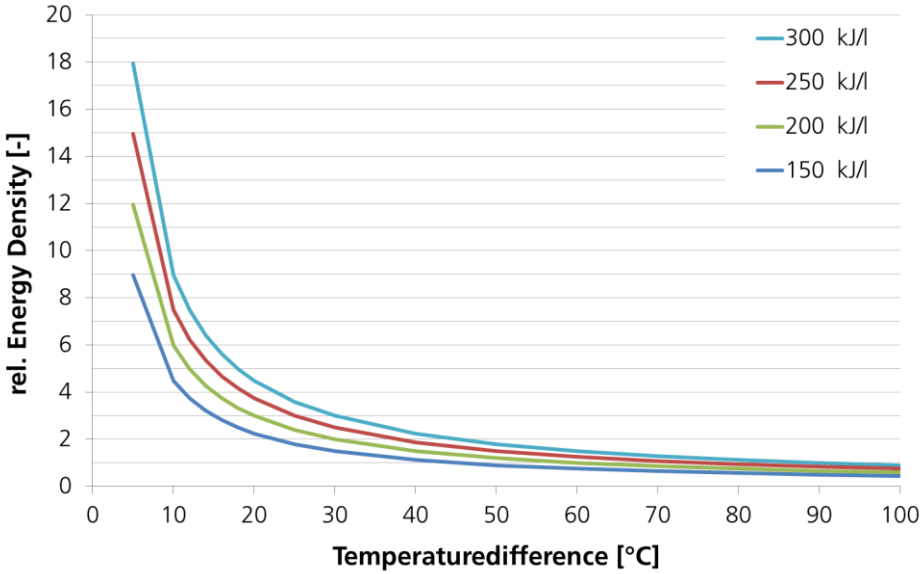
Latent Heat Storages

Comparison to Water

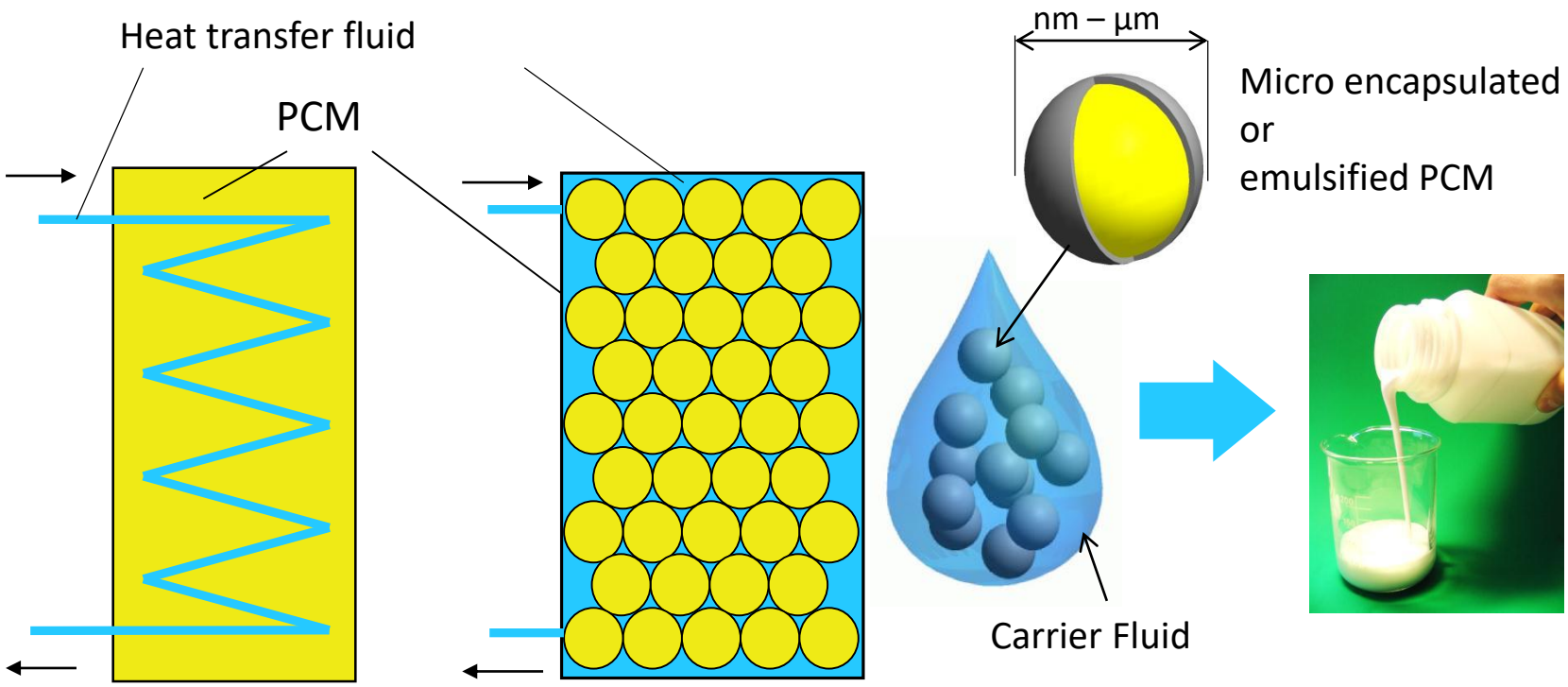




- Melting- and crystallization temperature range
- Super cooling
- Low specific heat capacity
  - ➔ Advantages to sensible material at small temperature differences
- Low thermal conductivity
  - ➔ Challenge to charge and discharge with high power

Latent Heat Storages

Storage Principles



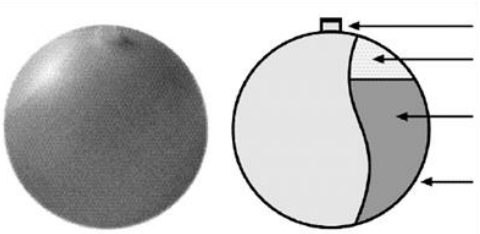
Immersed
Heat Exchanger

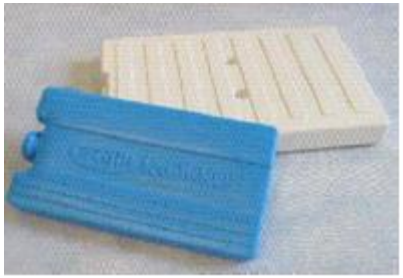
Macro capsules

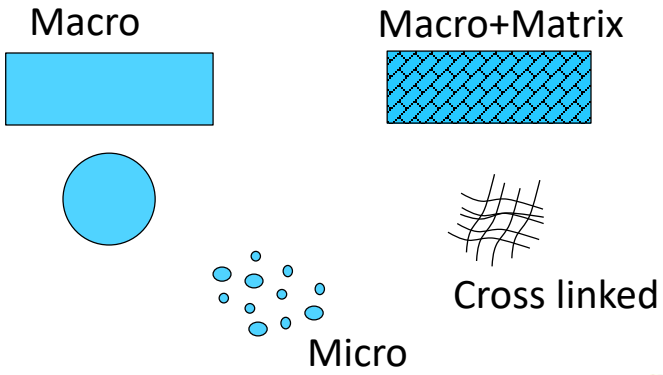
Phase Change Slurries
(PCS)

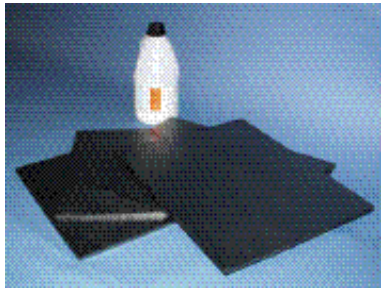
Macrocapsules

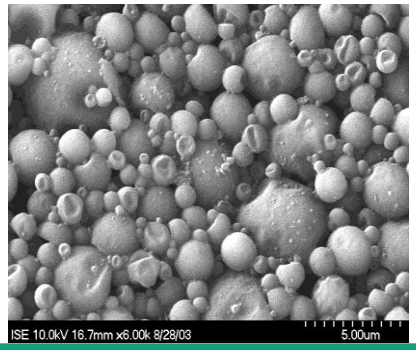
Examples for macro encapsulations











sources: Cristopia, teap, Rubitherm, SGL-Carbon, PlusIce

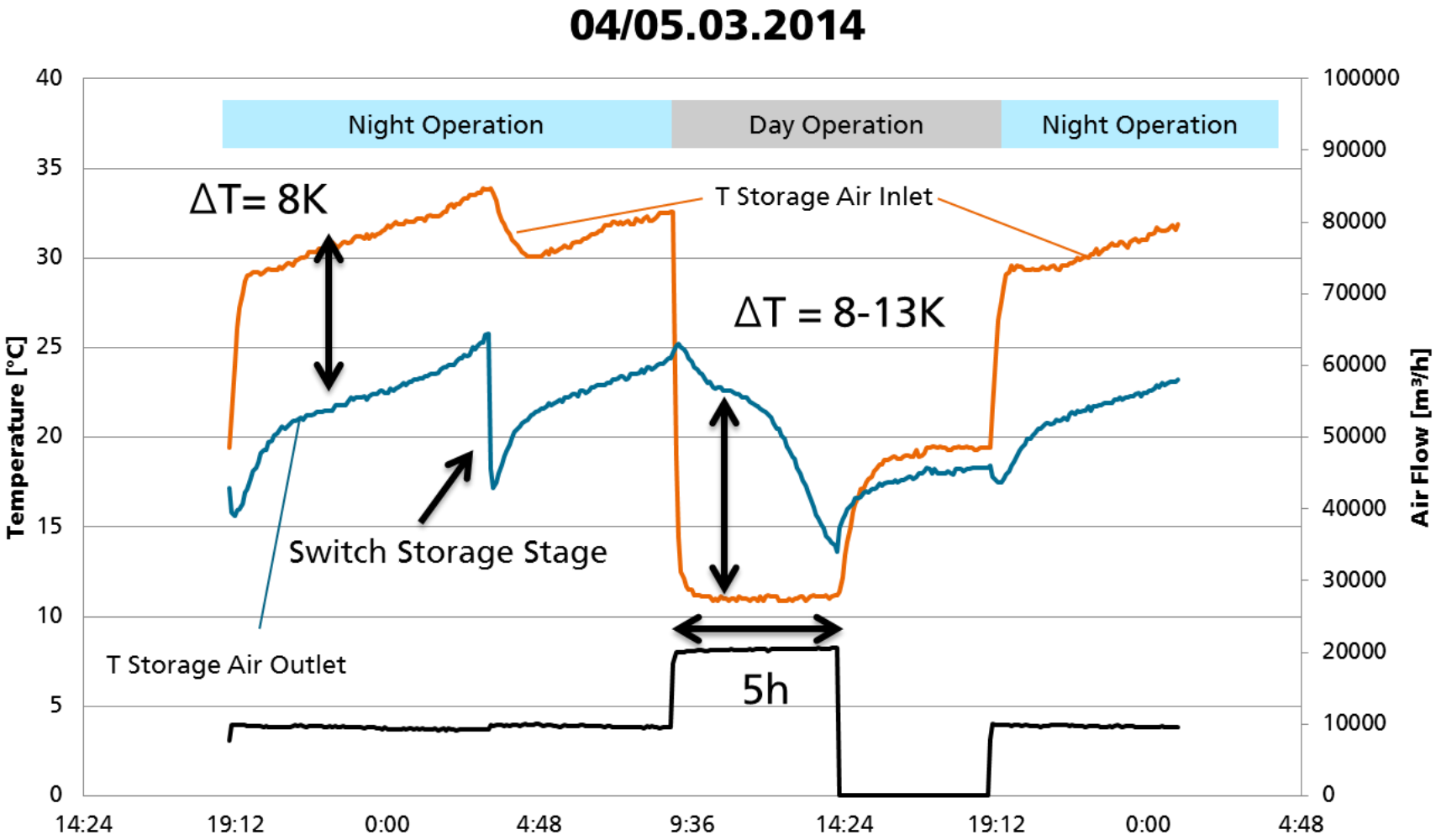
Application

Macrocapsule storage, courthouse Düsseldorf

- Storage in the fresh air system
  - Melting temperature 22 - 25°C
  - 11t PCM (Plate type macro capsules), ~600kWh (ΔT= 15K), ~25kWh/m³
- Winter operation
  - Storage of waste heat during the night (exhaust air from server)
  - ➔ Preheating of fresh air during the day
- Summer operation
  - Buffering cold during night (fresh air circulation)
  - ➔ Precooling fresh air during the day
- ➔ Usage of storage during summer and winter period ➔ high number of cycles

Courthouse Düsseldorf

Result



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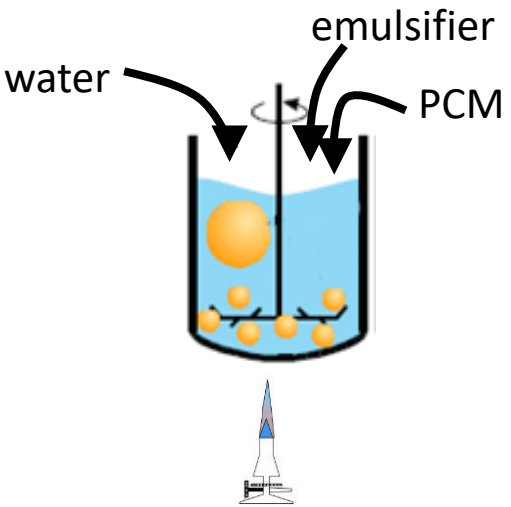
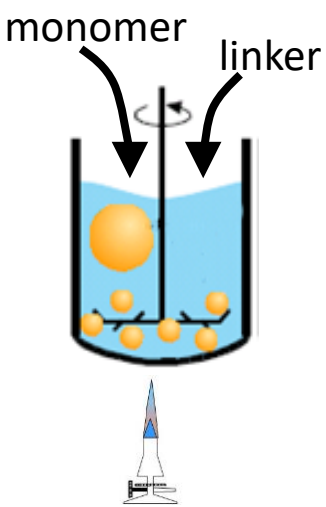
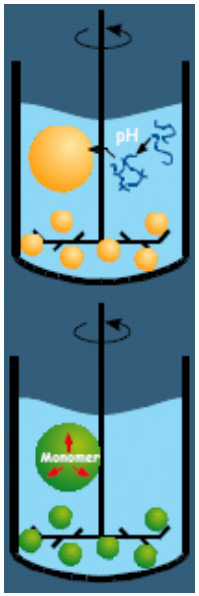
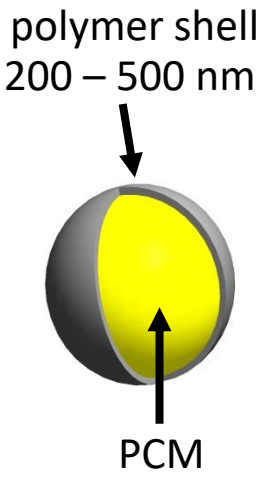
Microcapsules and PCM-Emulsions

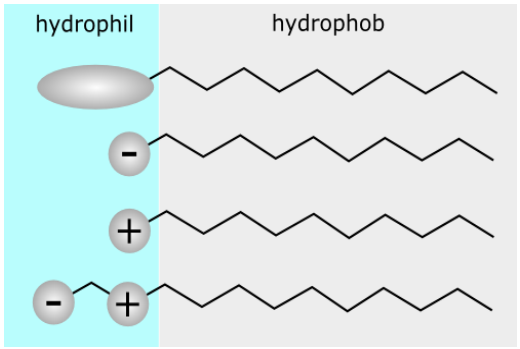
Processing

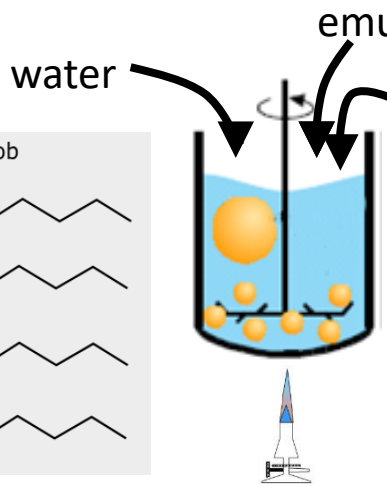


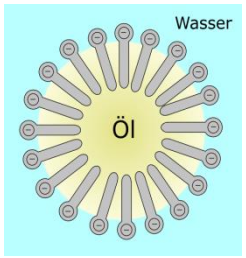


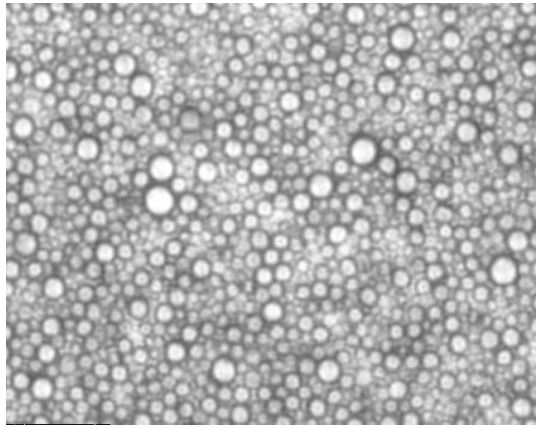












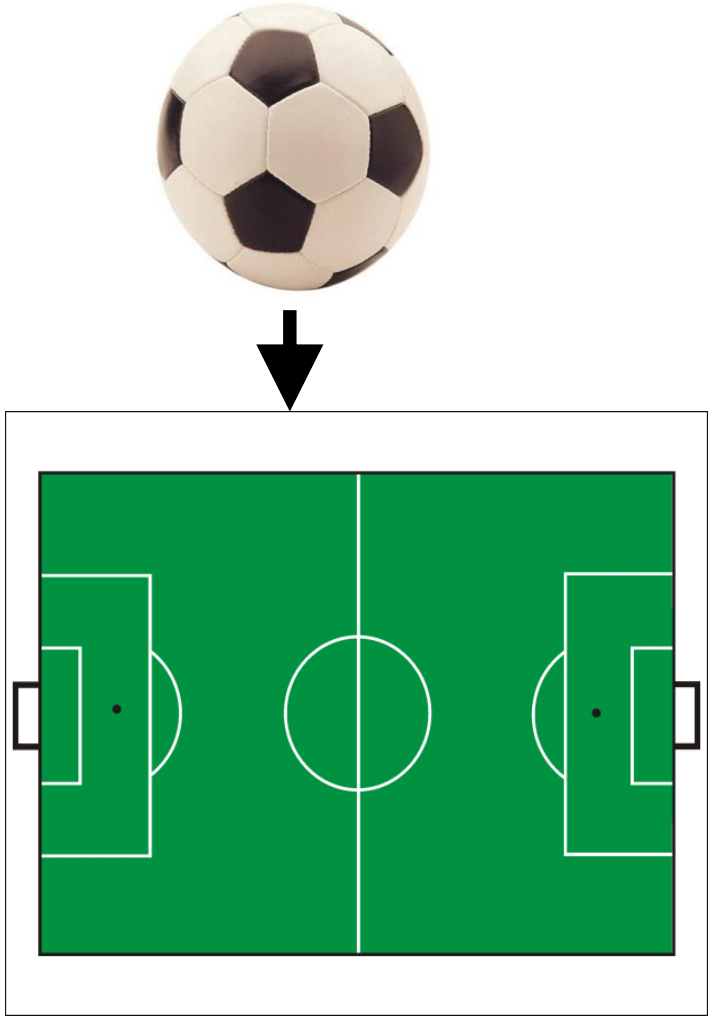
Microencapsulation and emulsification

Advantage

paraffin sphere D = 20 cm
volume approx. 4 L
surface approx. 0.126 m²

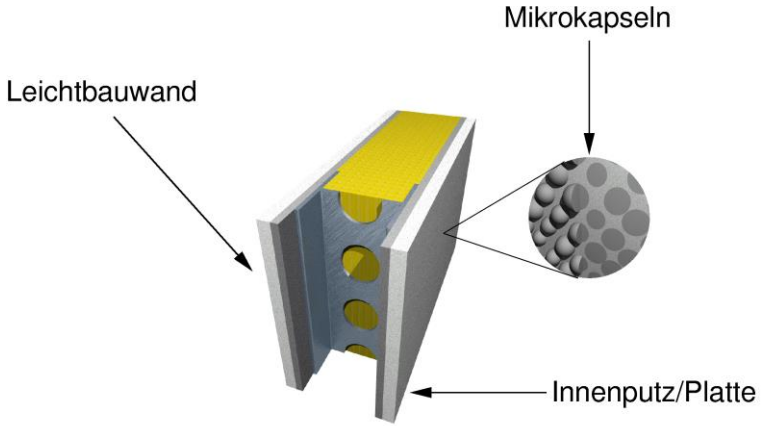
micro-encapsulation
emulsification

paraffin droplets D = 5 µm
inner surface 4800 m²

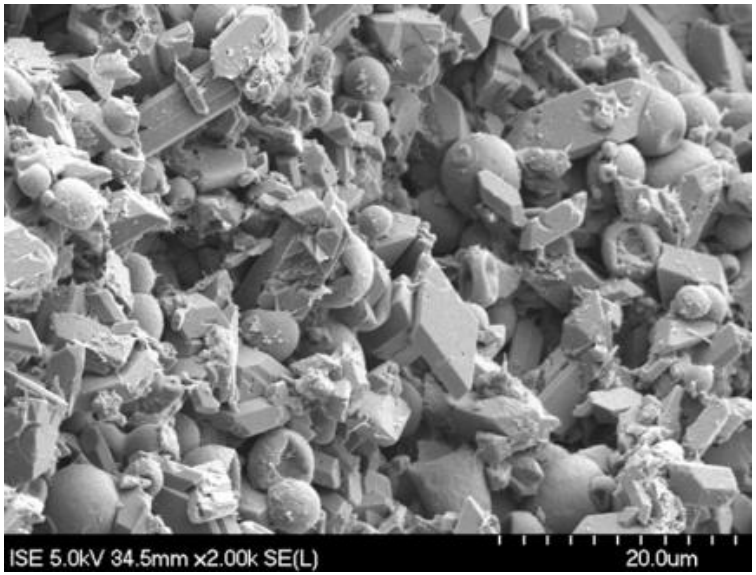


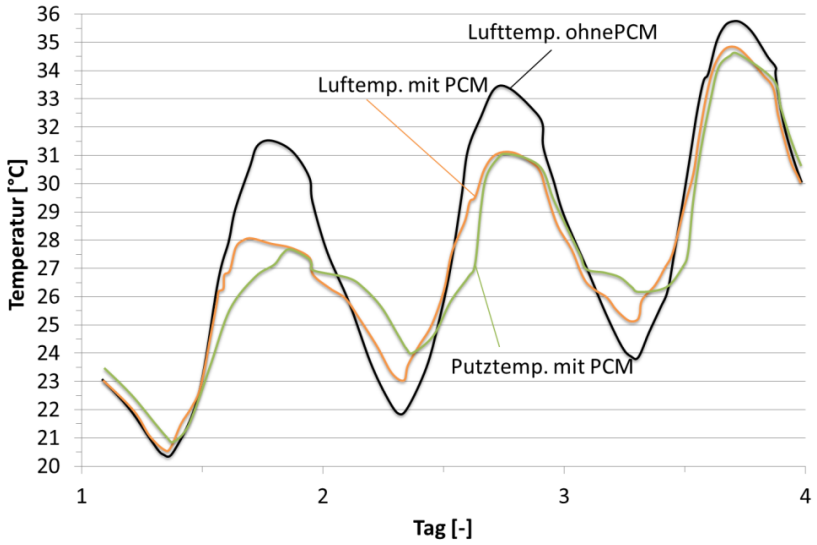
Application

Gypsum plaster with Microencapsulated PCM



- For passive cooling of buildings
- Fraction of microrcapsules
  20 – 30 wt.-% (2 -3 kg/m²)
- Melting temperature 21 – 26°C
- Regeneration with night air





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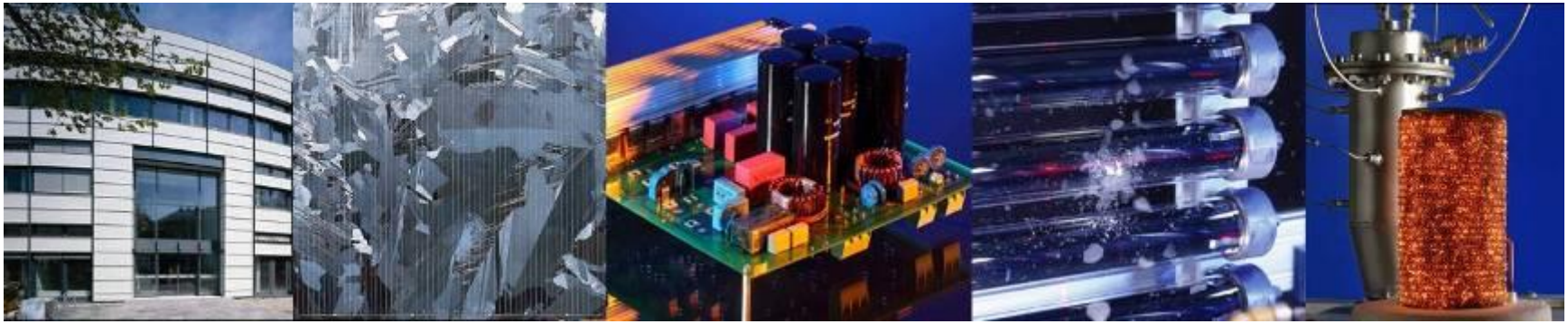
Summery

- Three basic principle for thermal storage: sensible, latent, thermo-chemical / sorption
- Latent heat storages store within the phase transition (solid/liquid)
  - Materials are available for a wide temperature range
  - Paraffins and salt hydrates are the most used materials
  - High storage densities within small temperature gradients compared to sensible heat storage materials
  - 3 basic storage principles I) Immersed heat exchanger, II) Macrocapsule, III) Phase Change Slurries
  - Examples for latent heat storage systems:
    - Macrocapsules in air conditioning systems,in cold water storages (not shown)
    - Microcapsules within gypsum plaster for passive cooling, PCM- Slurries as heat and cold transfer fluid

Thank you for your attention!



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