AEE INTEC

Material and Component Development for Thermal Energy Storage

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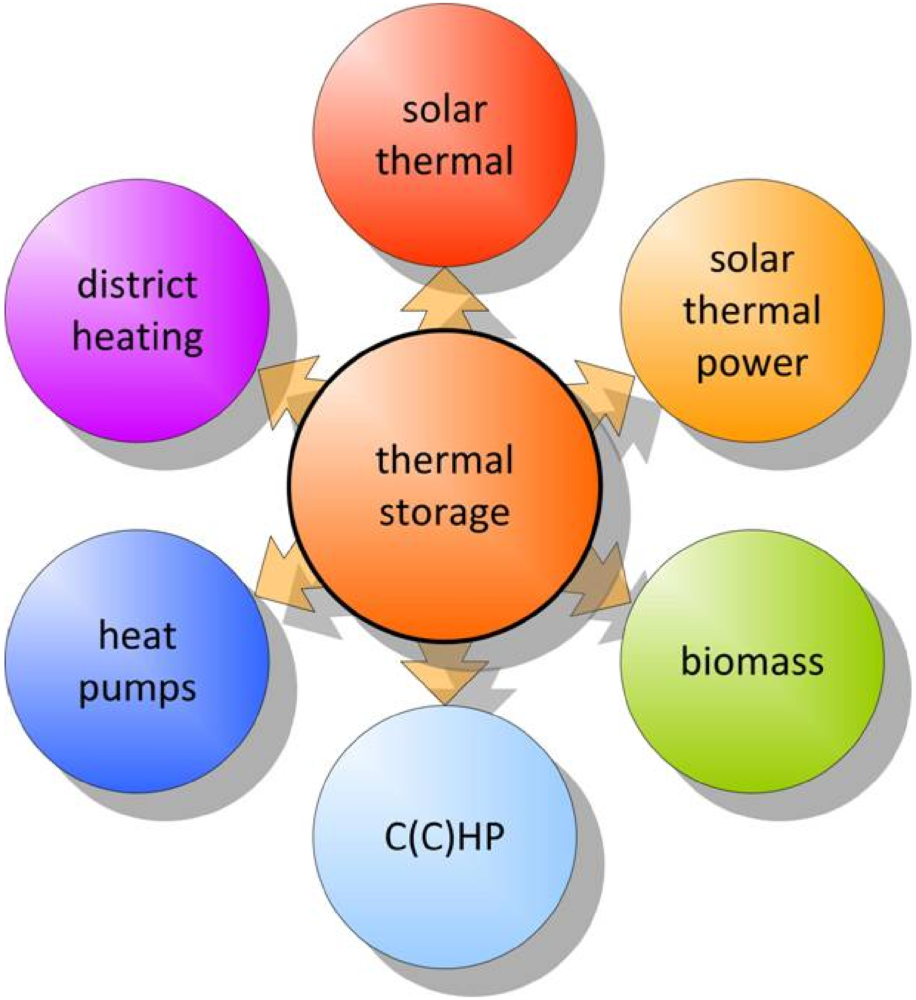
International Collaboration

Task58/Annex33

Material and Component Development for Thermal Energy Storage

- International Energy Agency joint research and development project
- Joint: Solar Heating and Cooling (SHC) and Energy Conservation through Energy Storage (ECES)
- 3-year duration, 2017-2019
- Materials and Application Experts (over 60 from 13 countries)
- Semi-annual experts meetings
- Work on common goals

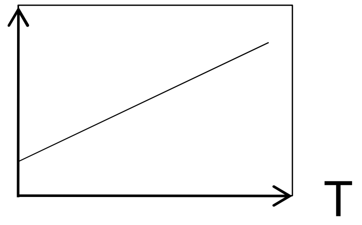
Thermal Energy Storage is a Key Enabling Technology



3 Main principles for Heat Storage

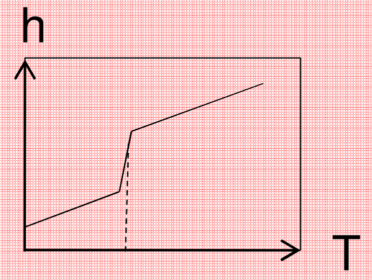
Sensible heat
- principle: heat capacity
- reservoirs, aquifers, ground/soil

h = stored heat

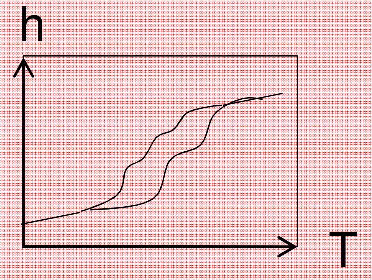


Compact TES

Latent heat
- principle: phase change (melting, evaporation)
- water, organic and inorganic PCMs



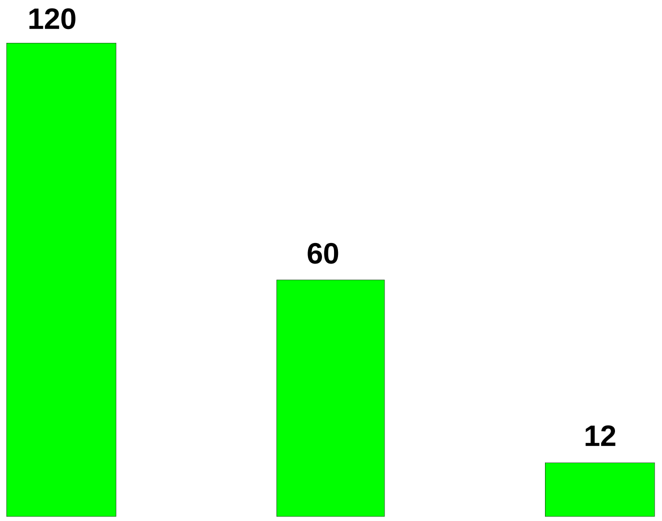
Sorption heat and **Chemical heat**
- principle: physical (adhesion) or chemical bond (reaction enthalpy)
- a**d**sorption and a**b**sorption and chemical reactions



Compact Thermal Energy Storage

If available volume limited→ Compact storage

Volume (m^3) of a seasonal storage for an energy efficient single family house



	Sensible	Latent	Chemical	
Storage density	110	250	500-3000	MJ/m^3
	31	70	140-830	kWh/m^3

Scope of T58A33

Advanced materials for latent (PCM) and chemical thermal energy storage (TCM) materials.

Three different scales:

- **Material properties**,
  behaviour from molecular to bulk scale, material synthesis, micro-scale mass transport and sorption reactions;
- **Material performance in components**
  materials behaviour, also within the storage system; heat, mass, and vapour transport, wall-wall and wall-material interactions, reactor design;
- **Storage system implementation**
  performance of a storage within a heating or cooling system, including e.g. economical feasibility studies, case studies, and system tests.

Subtask structure

PCM	TCM

Subtask 1: “Energy Relevant Applications for an Application-oriented Development of Improved Storage Materials”

Andreas Hauer (ZAE, DE) /Wim van Helden(AEE Intec, A)

Subtask 2: “Development and Characterization of Improved Materials”

PCM	TCM
Stefan Gschwander (ISE, DE)	Alenka Ristic (NIC, SI)

Subtask 3: “Measuring Procedures and Testing under Application Conditions”

PCM	TCM
Christoph Rathgeber (ZAE, DE)	Daniel Lager (AIT, A)

Subtask 4: “Component Design for innovative TES Materials”

PCM	TCM
(Ana Lazaro, Uni Zaragoza, ES)	Benjamin Fumey (EMPA, CH)

T58A33 experts group
Ljubljana, April 2018

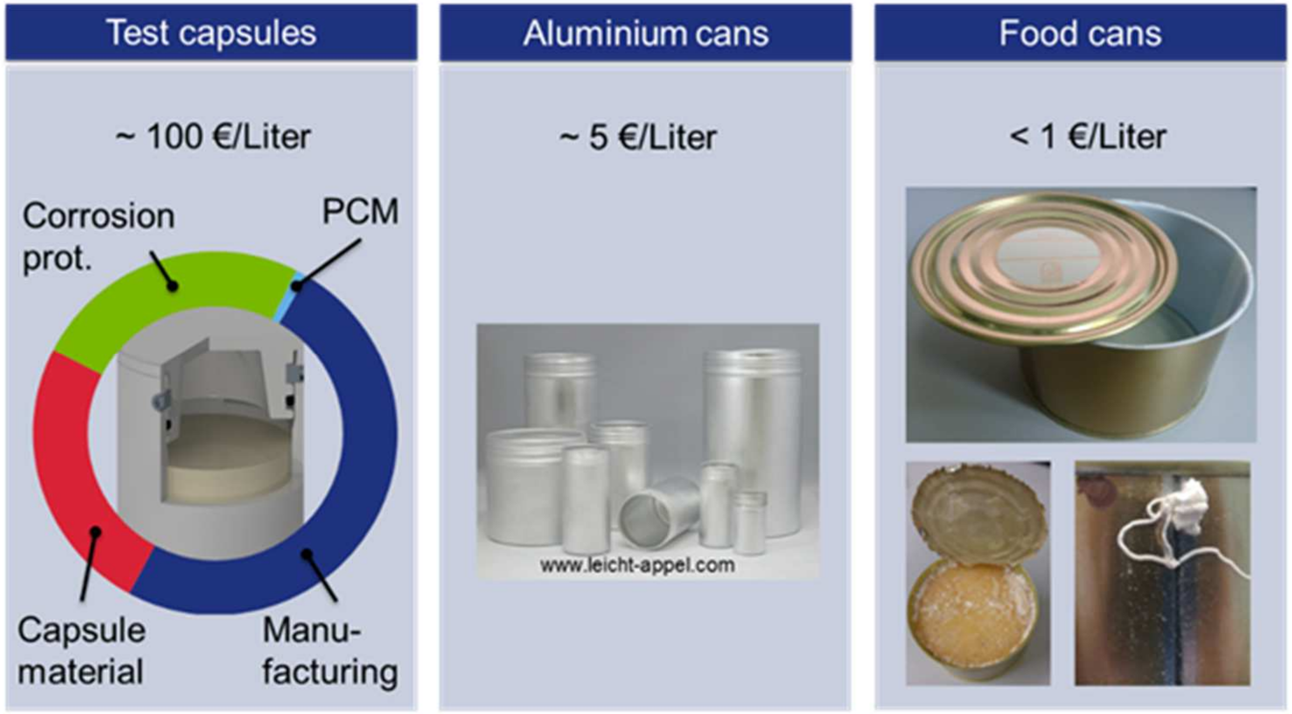
Materials and component development examples

- PCM components
- Solid sorption
- Hydrates and ammoniates
- Materials characterisation and testing
- Open and closed systems
- Seasonal storage systems
- Storage for industry

PCM components development

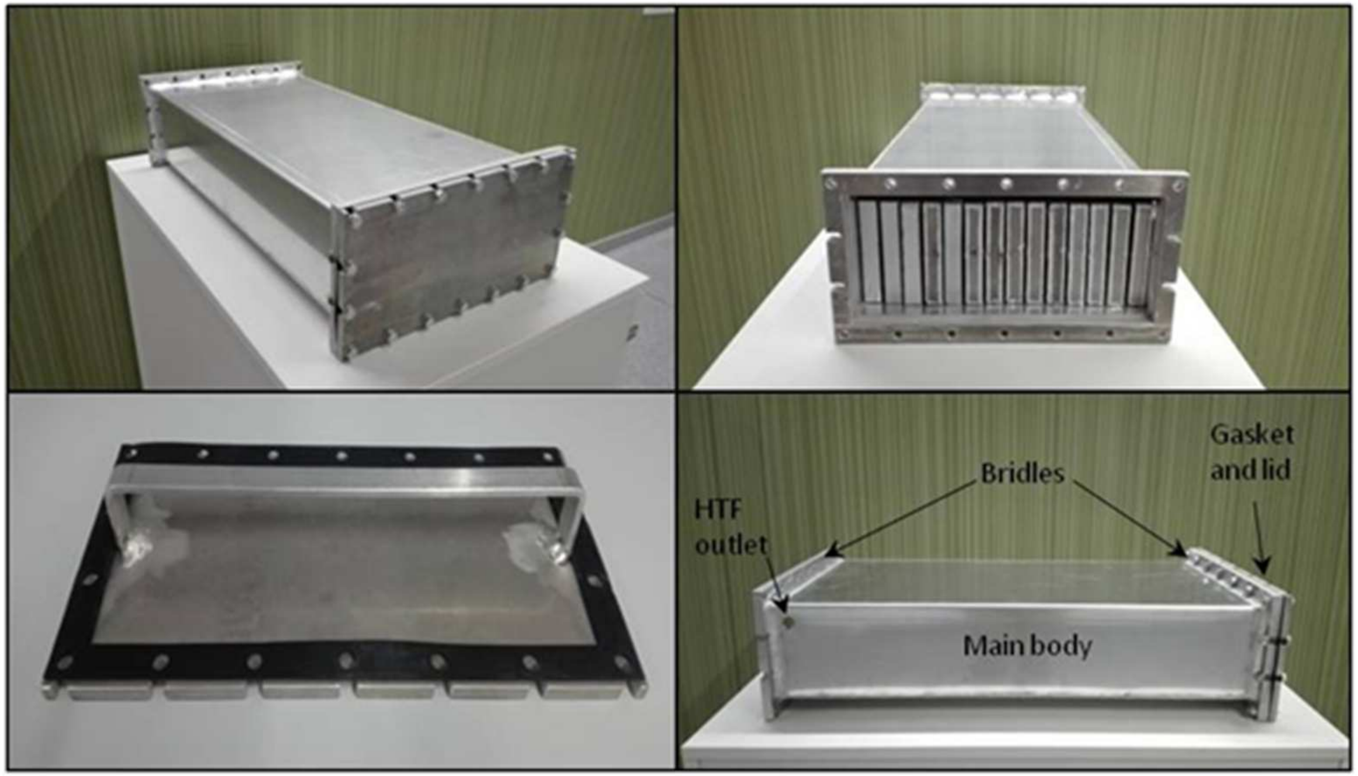
University of Bayreuth (DE) is working on macro-encapsuled PCM for heat transport.

Figure shows cost comparison of macro-encapsulated test capsules and low-cost alternatives

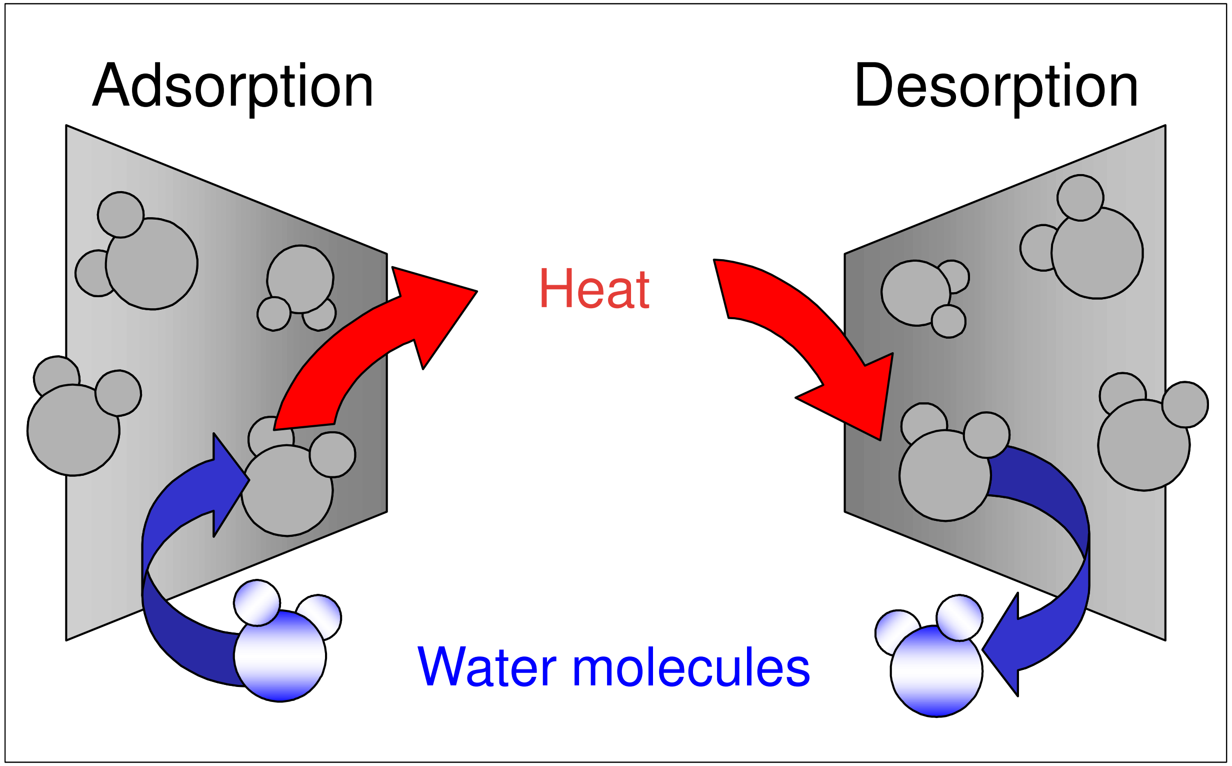


PCM components development

University of the Basque Country (ES) has developed a compact-plate PCM TES for heating and DHW. Cycling behaviour is investigated in prototype.



(Solid) sorption



Zeolites:

Charging

Temperature:

120 – 300 °C

Discharging

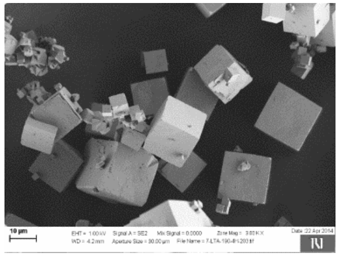
Temperature:

50 – 200 °C

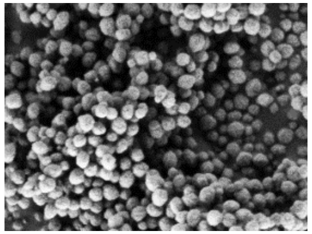
E. Lävemann, ZAE Bayern

Materials Development - Sorption

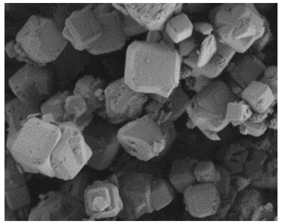
National Institute of Chemistry – Slovenia
Development of microporous aluminophosphates
Improved performance



$AlPO_4$-LTA: cubes of 10 to 20 µm



MOF-801: round particles of 200 nm

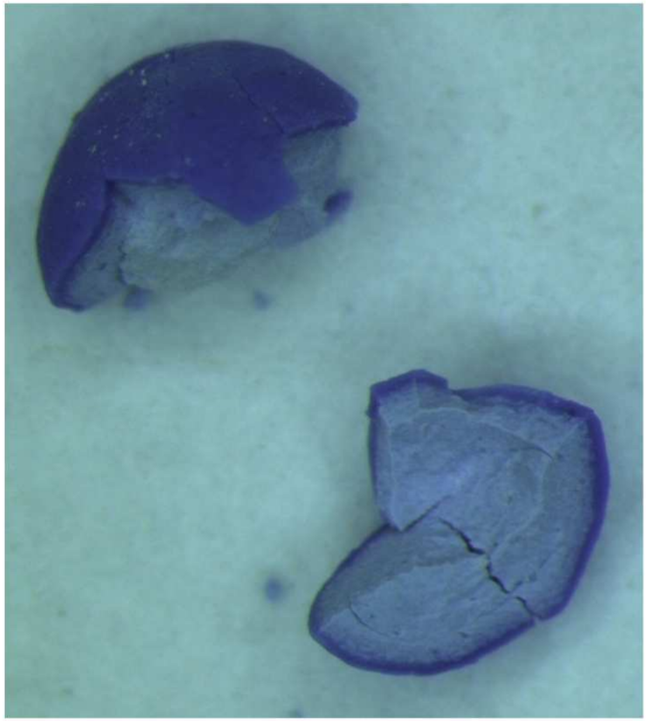


Zeolite 4A: cubes of 2 µm

	Maximum water uptake (g/g)	Energy storage capacity (Wh/kg)	Charging temperature (°C)	Decrease in water capacity (%) after 20 cycles
$AlPO_4$-LTA	0.42	373	65	<0.3
MOF -801	0.36	323	80	> 3
Zeolite 4A	0.28	350	300	<0.3

Materials development – Novel TCM Ammonia as sorbate

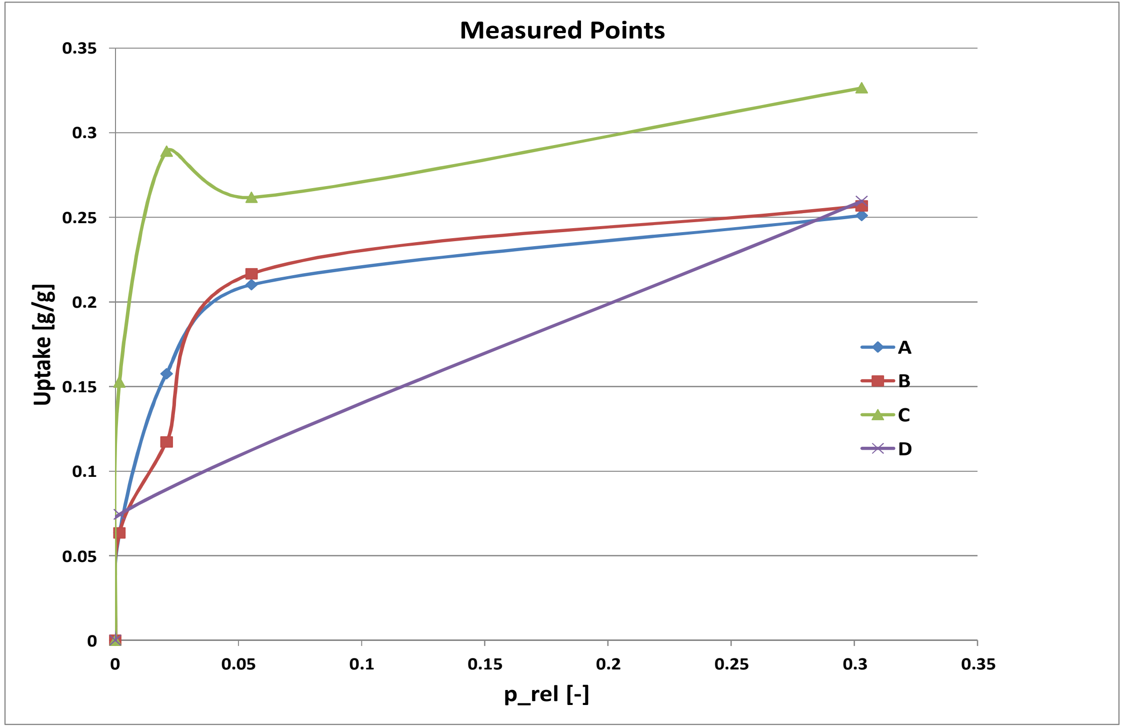
$[Cu(NH_3)_4](SO_4)$ on zeolithe



$[Cu(NH_3)_4](SO_4)$ on zeolithe

Copper sulfate with ammonia: 1770 kJ/kg storage density; volume expansion controlled by integration into zeolite (215 kJ/kg) (TU Vienna, AT)

Subtask 3T Measurement procedure improvement for TCM

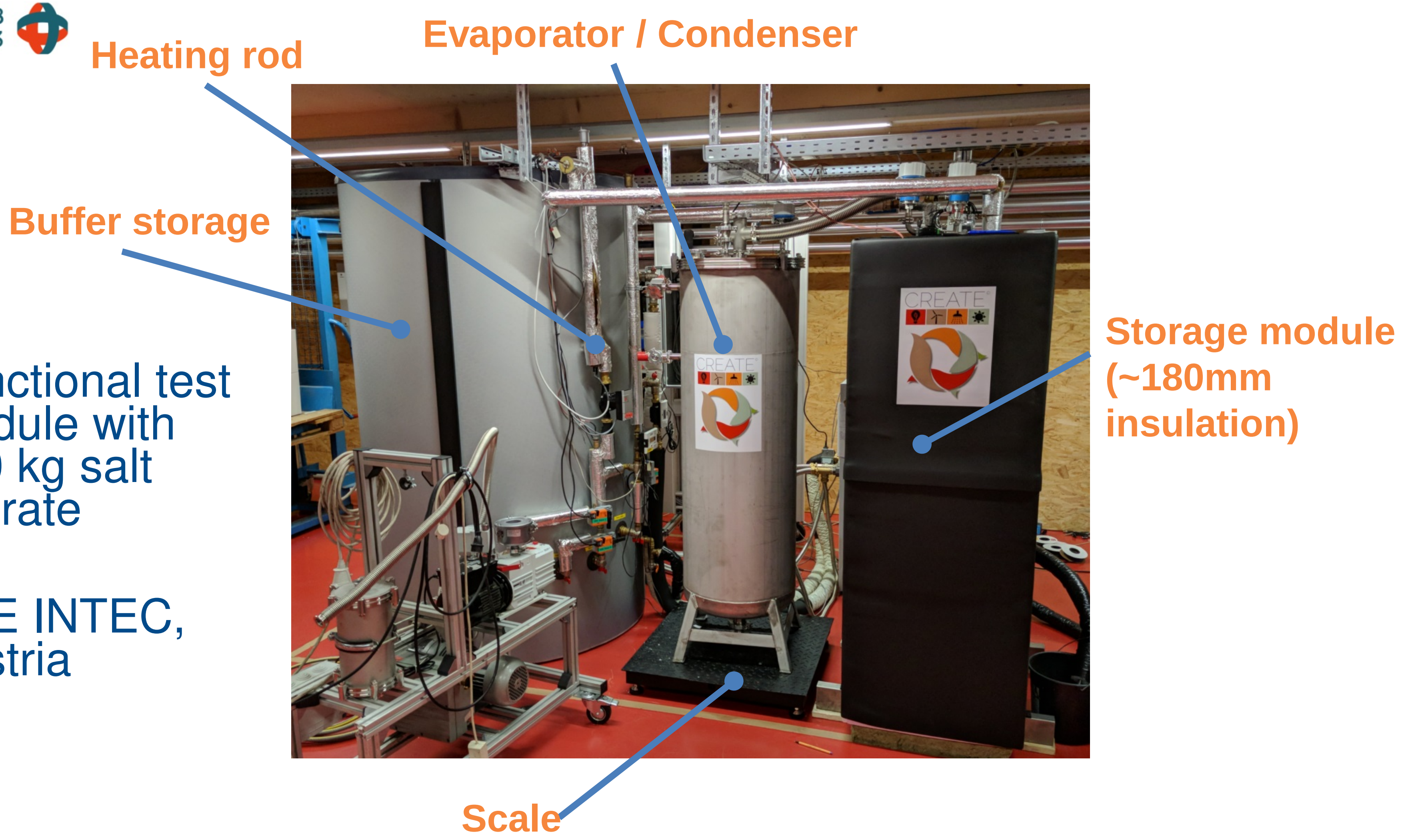


Results for water uptake of zeolite sample by four different partners

Analysis of possible reasons for disagreement and re-definition of measurement procedure

Compact seasonal thermal storage system with salt hydrates

SHC 58 | ECES 33



Functional test module with 200 kg salt hydrate

AEE INTEC, Austria

Open Sorption

OFFSOR Project (FHOÖ Wels, AT)

Open Sorption Technology for long-term Thermal Storage

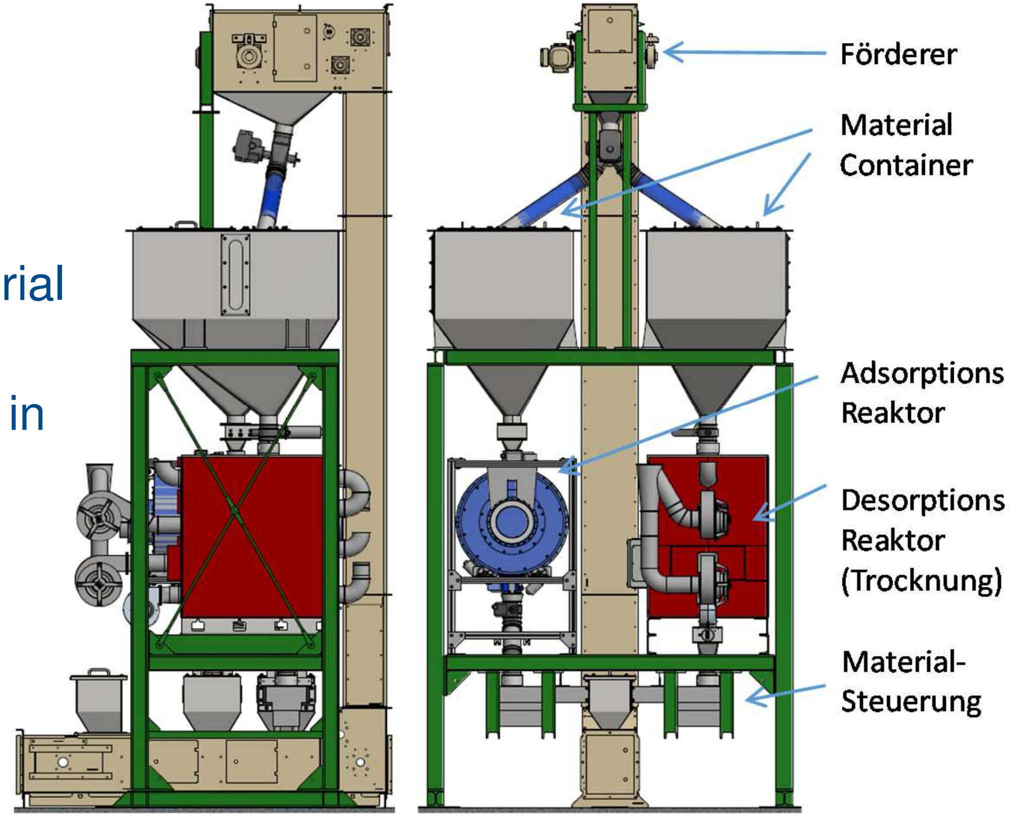
Development goals

Process technology:
- Material transport
- Abrasion of storage material

Optimisation of desorption in summer

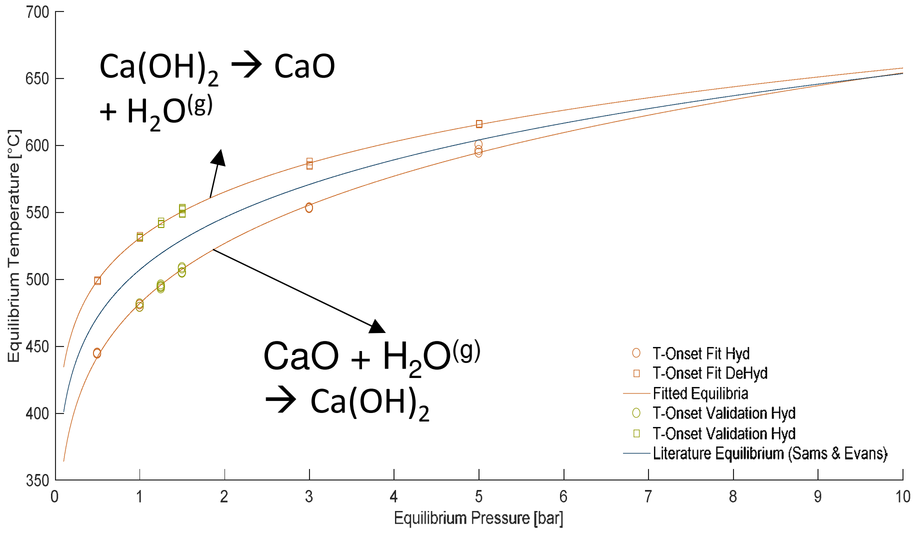
Preparation of moist air in winter

Control strategy



Component Development

High temperature TES: Oxide – Hydroxide Reaction



TU Munich:

Finalized construction of a 10kW pressurized fluidized bed pilot reactor

(30 l, up to 7 bar and 700 °C, Nitrogen and Steam Atmosphere)

In conclusion

- Heat and cold use if of major importance in the global energy system
- Thermal Storage is an enabling technology for a broad field of applications/technologies
- Long-term ongoing collaboration between materials experts and systems experts
- IEA SHC/ECES Task58/Annex33 is delivering results in materials and component development for (compact) thermal energy storage technologies
- Continued effort is required to arrive at optimal TES solutions

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IDEA TO ACTION

Thank you
for your Attention