SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

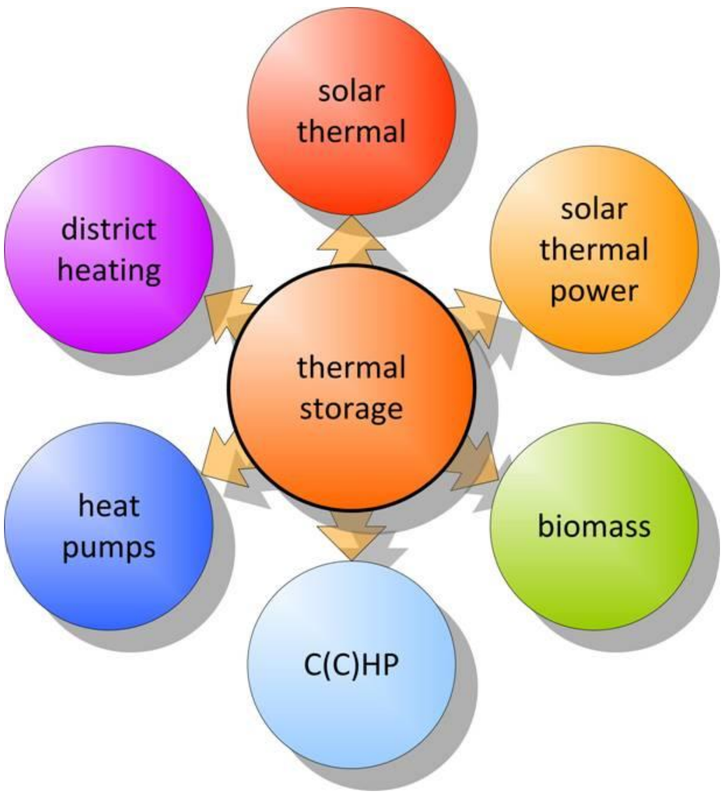
Task58/Annex33

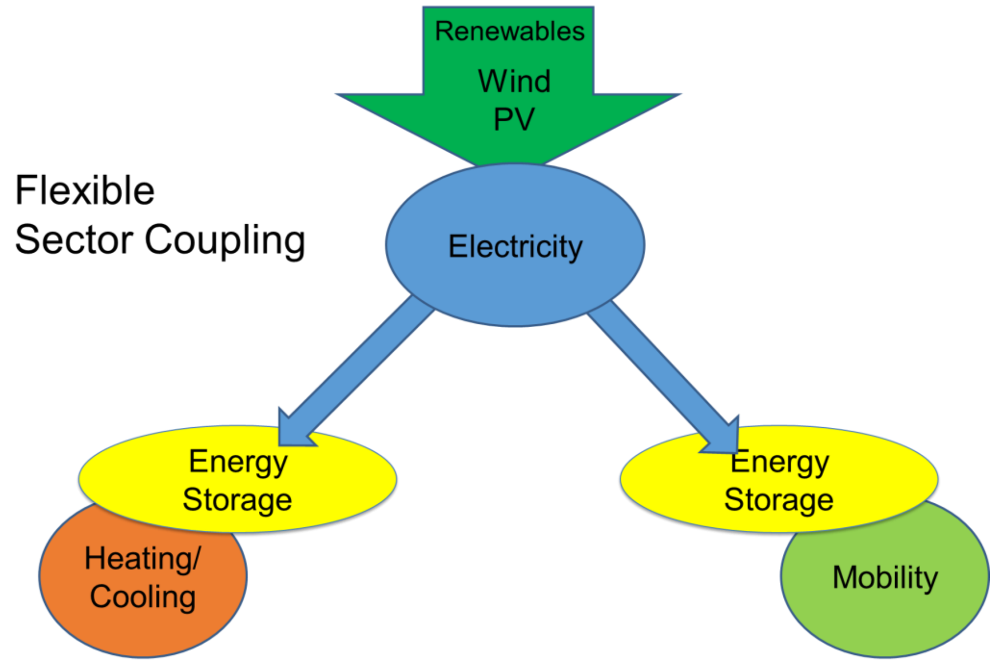
Materials and Component Development for Thermal Energy Storage

SHC | 58
ECES | 33

Wim van Helden, AEE INTEC, Austria; w.vanhelden@aee.at
IEA SHC Solar Academy
Webinar, 28 November 2019

Thermal Energy Storage is a Key Enabling Technology

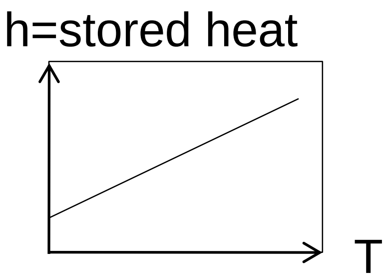




Source: ZAE Bayern, IEA ECES Annex 35

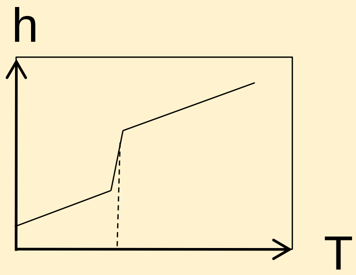
3 Main principles for Heat Storage

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

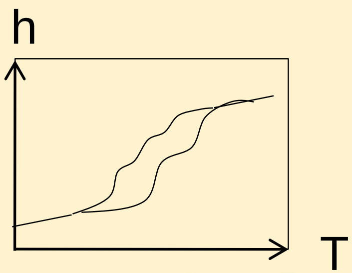


Compact TES

- **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



Why
Compact Thermal Energy Storage

- Higher storage capacity
- Added value if cost of volume is high
- Less losses
- Especially attractive for longer term storage
- Added functionality

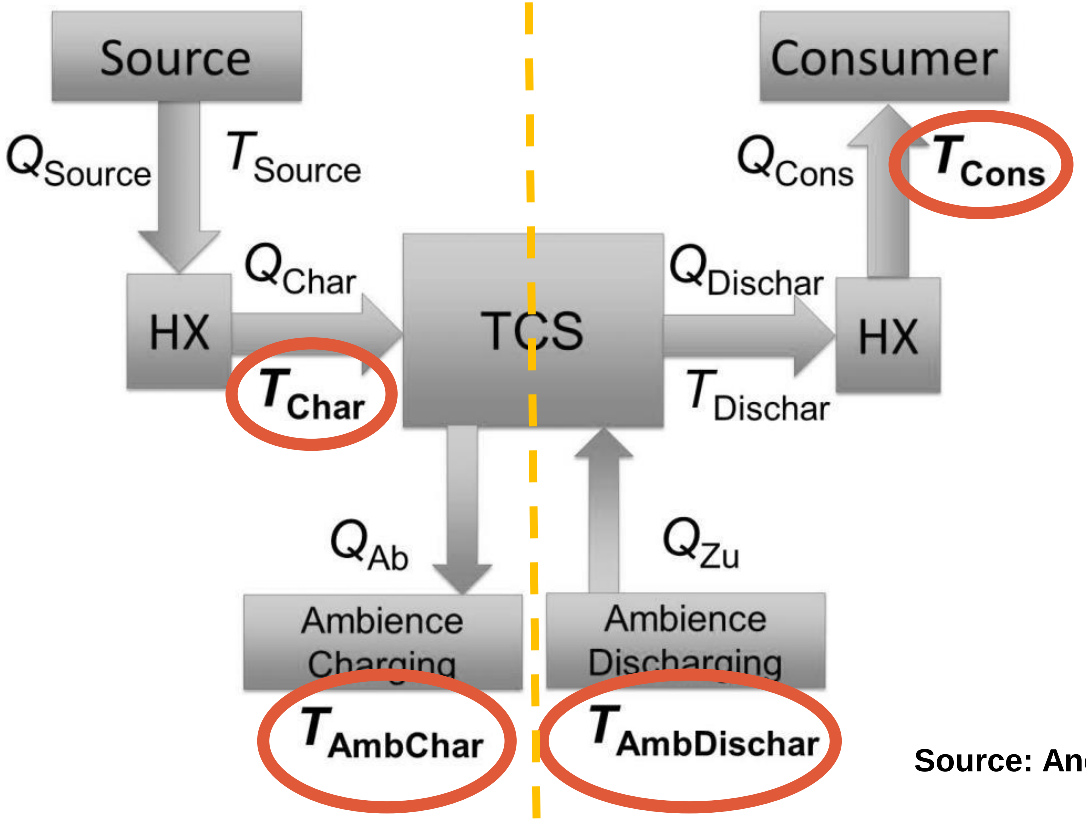
  E.g. Fixed temperature for PCM, drying capacity of sorption storage

What are the challenges

- Thermal storage performance is dependent on the application
- Temperatures at charging and discharging
- No direct relation between the material data and the performance of the material in a TES system in an application

4-Temperature-Approach for TCM

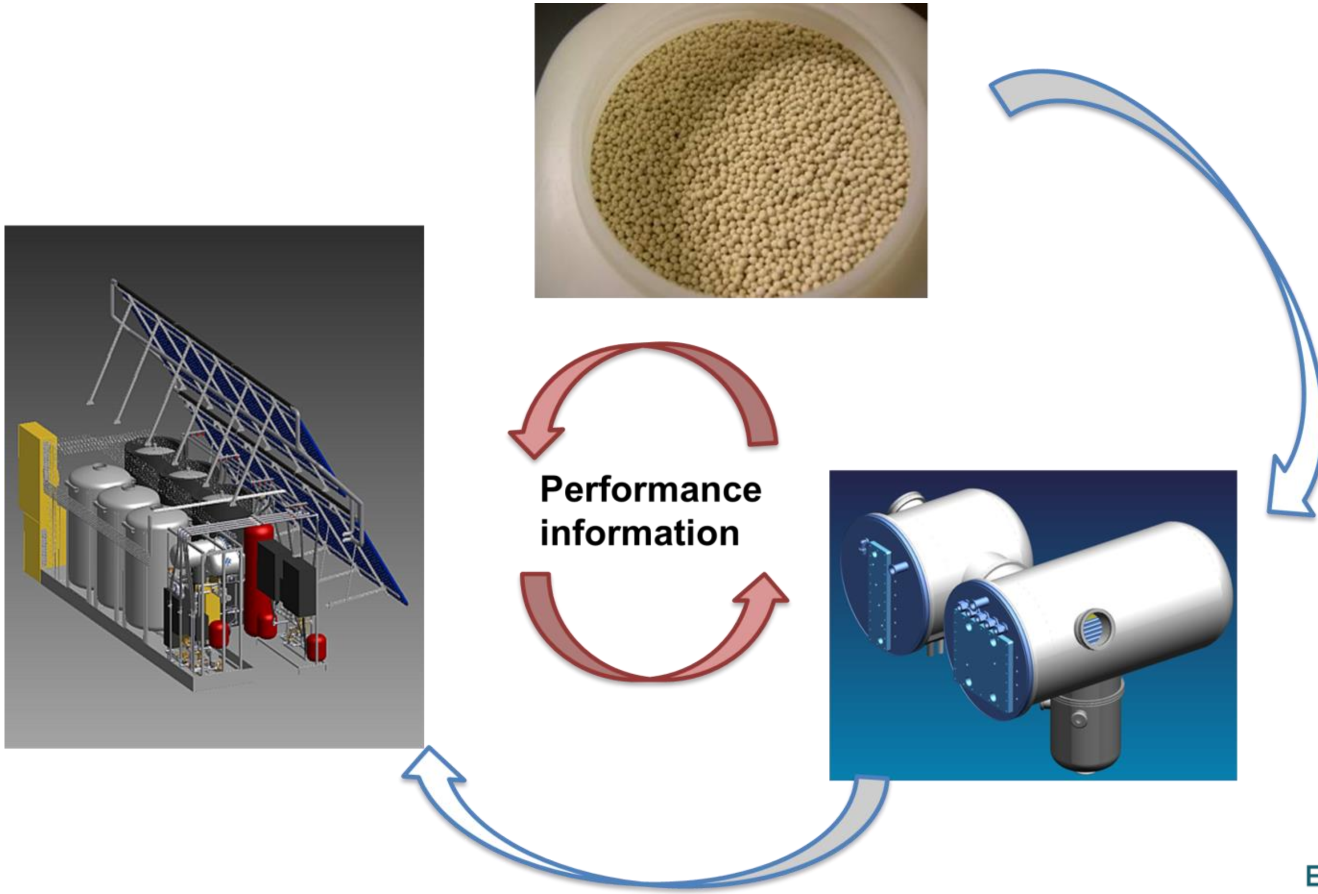
Charging



Discharging

Source: Andreas Hauer, ZAE Bayern

Design approach: interaction between materials development and system integration



International Collaboration within IEA

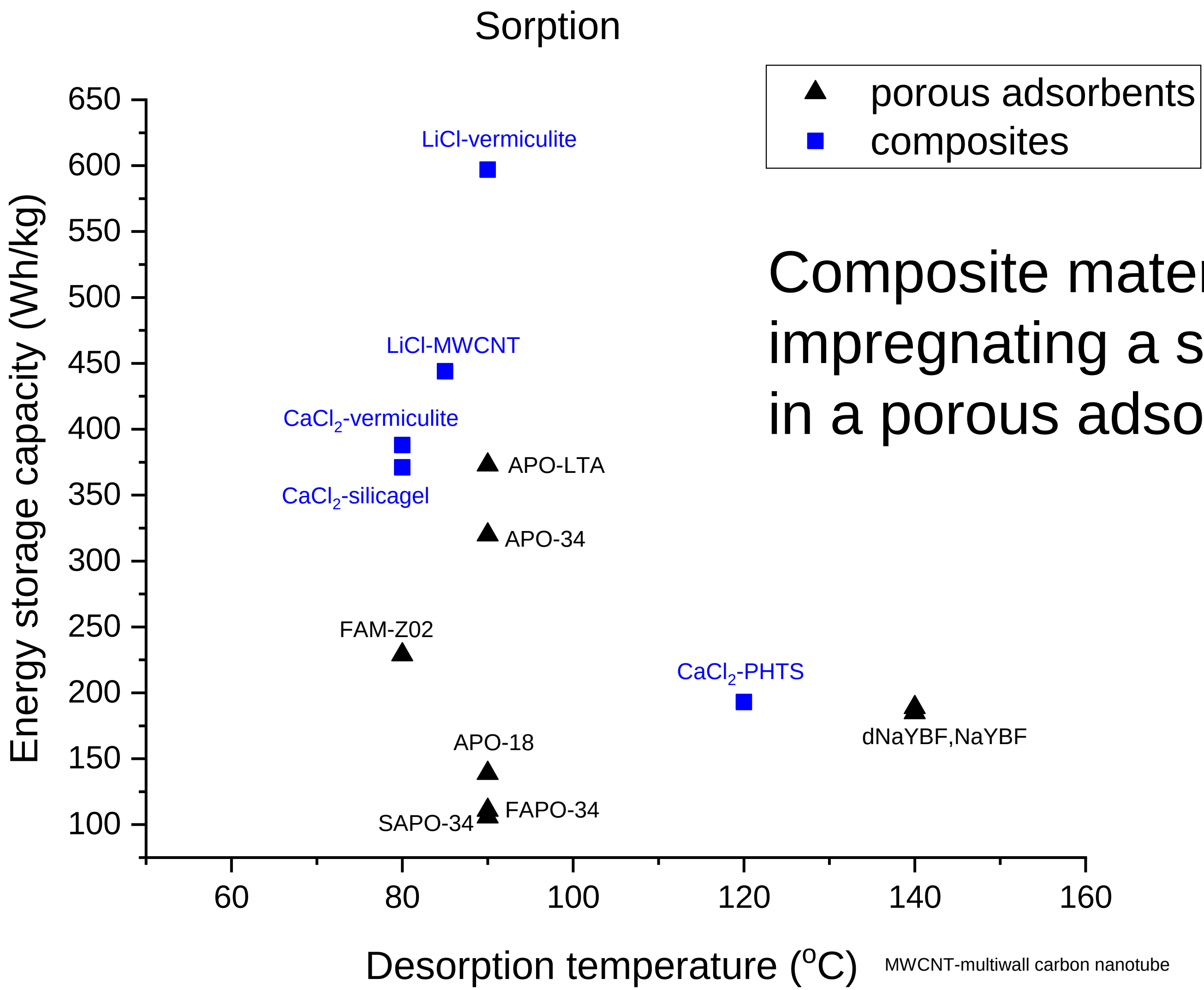
Task58/Annex33
Material and Component Development for Thermal Energy Storage

- 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

Task 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"	
Stefan Gschwander (ISE, DE)	Alenka Ristic (NIC, SI)
Subtask 3: "Measuring Procedures and Testing under Application Conditions"	
Christoph Rathgeber (ZAE, DE)	Daniel Lager (AIT, A)
Subtask 4: "Component Design for innovative TES Materials"	
(Ana Lazaro, Uni Zaragoza, ES)	Benjamin Fumey (EMPA, CH)

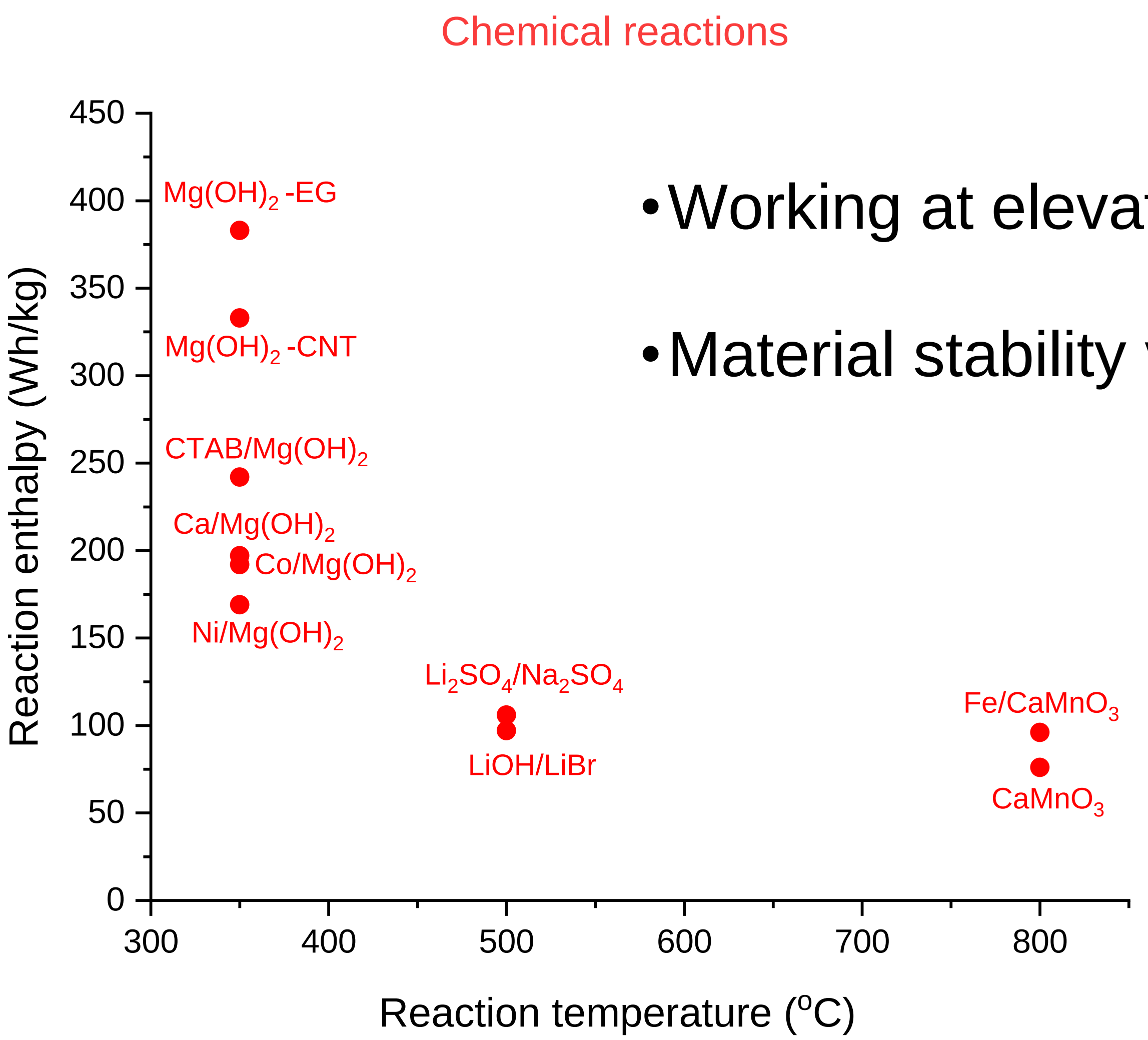
New sorption materials developed



MWCNT-multiwall carbon nanotube

Composite materials: impregnating a salt hydrate in a porous adsorbent

New chemical reactions developed



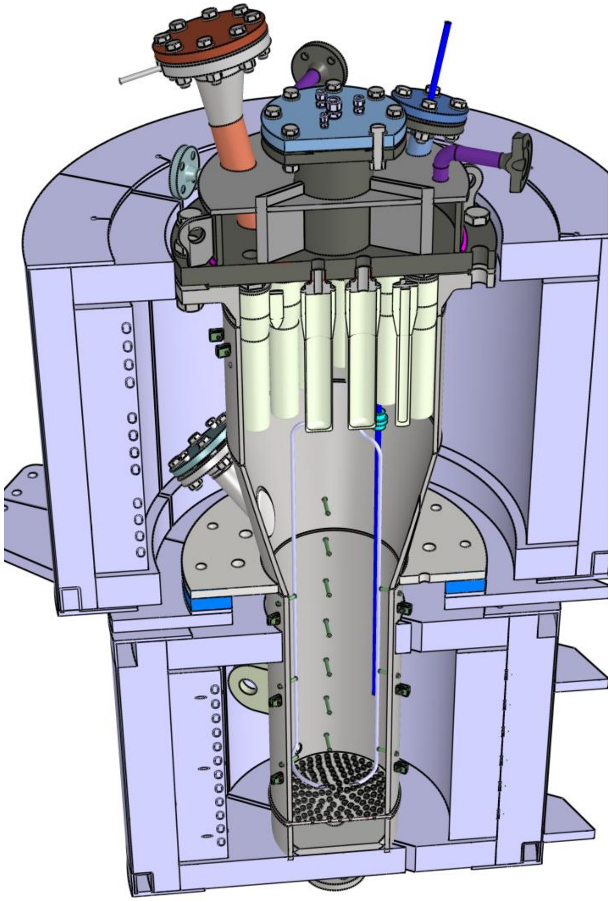
- Working at elevated temperatures
- Material stability very challenging

Component development – TES for industry

TWIST – Thermochemical Energy Storage in a fluidised bed reactor for industrial and power applications

$$CaO(s) + H_2O(g) \leftrightarrow Ca(OH)_2(s) + 104\ kJ/mol$$

- $CaO/Ca(OH)_2$ offers high storage density at low cost, but suffers from low conductivity
- Goal: development of a fluidized bed offering high power & separation of power and capacity
- Approach/Methods: Systematic characterization of all aspects of the material and reactor design
- Results:
  - Technical feasibility up to 20 cycles demonstrated
  - Heat transfer coefficients up to 350 W/m²K demonstrated, nevertheless the system remains heat transfer limited
  - 10 kWch pilot reactor is currently being taken in operation



Technical University Munich, Institute for Energy Systems

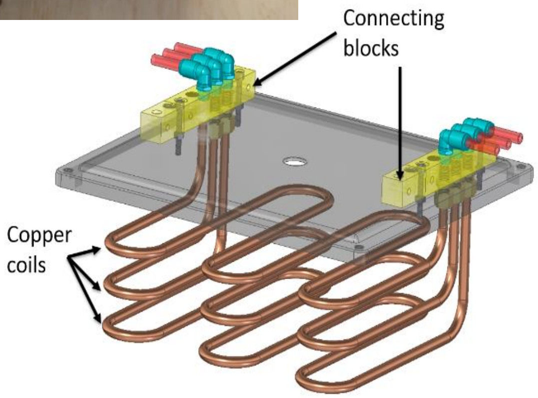
Component Design

Design Rules for PCM-Heat Exchanger

In order to develop design rules for PCM-Heat Exchanger (HX), we must first determine how to compare different HX configurations (size, geometry, PCM, operating conditions).

Various PCM-HX are experimentally characterized in order to obtain enough data to develop comparison metrics (power, energy, temperatures, time for charge and discharge, etc.)

The results are currently processed using various possible approaches and scenarios for PCM-HX comparisons.



Two PCM-HX configuration studies: finned tubes (top) and coils (bottom)

DALHOUSIE UNIVERSITY

Lab of Applied Multiphase Thermal Engineering

SHC 58 ECES 33

SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

Compact seasonal thermal storage system with salt hydrates

Functional test module with 200 kg salt hydrate

AEE INTEC, Austria

CREATE project

AEE INTEC

SHC 58 | ECES 33
SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

Further Development of CTES

Thermal energy storage is **needed** to:

- Replace fossil supply of heat demand
- Reduce necessity for large electricity transport capacity increase

What is needed: **Cost reduction** through

- Materials development
- Component development
- System integration

First cost-effective **applications** in

- Power to Heat
- Industrial heat
- Added functionality

Next Steps in CTES R&D

- Continue with the design approach
- Couple CTES R&D to the high potential application areas
- Find novel ways for the development process
- Formulate new challenges for continued IEA collaboration
- Address some challenges through Mission Innovation
    - Setting up a roadmap for TESMAP: Thermal Energy Storage Materials Acceleration Platform
- Provide decision makers with good information

www.iea-shc.org

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY