SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Task67/Task40
Compact thermal energy storage materials within components within systems

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T67/T40: Compact Thermal Energy Storage Materials within Components within Systems

Task67/Task40 is a joint Task between the IEA programmes

Solar Heating and Cooling (SHC)
and
Energy Storage (ES)

More than 60 experts from 14 countries worldwide collaborated.

Start: June 2021; End: September 2024

Task structure

	Subtasks	Subtask Lead
A	Material Characterisation and Database	Daniel Lager, AIT, Austria
B	CTES Material Improvement	Stefania Doppiu, CIC energiGUNE, Spain
C	State of Charge – SoC Determination	Gerald Englmair, DTU, Denmark (for PCM) Reda Djebbar, NRCan, Canada (for TCM)
D	Stability of PCM and TCM	Christoph Rathgeber, ZAE Bayern, Germany
E	Effective Component Performance With Innovative Materials	Benjamin Fumey, Empa, Switzerland (for TCM); Ana Lazaro, Univ. of Zaragoza, Spain and Andreas König-Haagen, Univ. Basque Country, Spain (for PCM)

Scope

- CTES (Compact Thermal Energy Storage) materials
  - Phase Change Materials (PCM)
  - Thermochemical Materials (TCM)

- CTES material…
  …characterization
  …development
  …improvement
  …testing in components (heat exchangers, reactors)

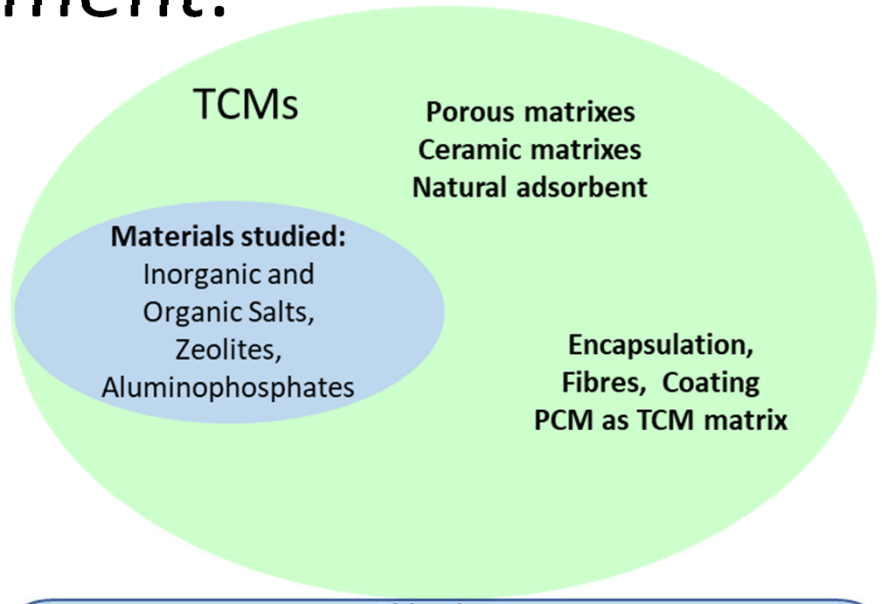
PCM
(e.g. ice, paraffins, salt hydrates)

TCM
(e.g. zeolite+water, NaOH+water)

Goals

- to have a better understanding of the factors that influence the storage density and the performance degradation of CTES materials
- to be able to characterize these materials in a reliable and reproducible manner
- to have methods to effectively determine the state of charge of a CTES
- to have better knowledge on how to design optimized heat exchangers and reactors or CTES technologies

Materials Development: TCM



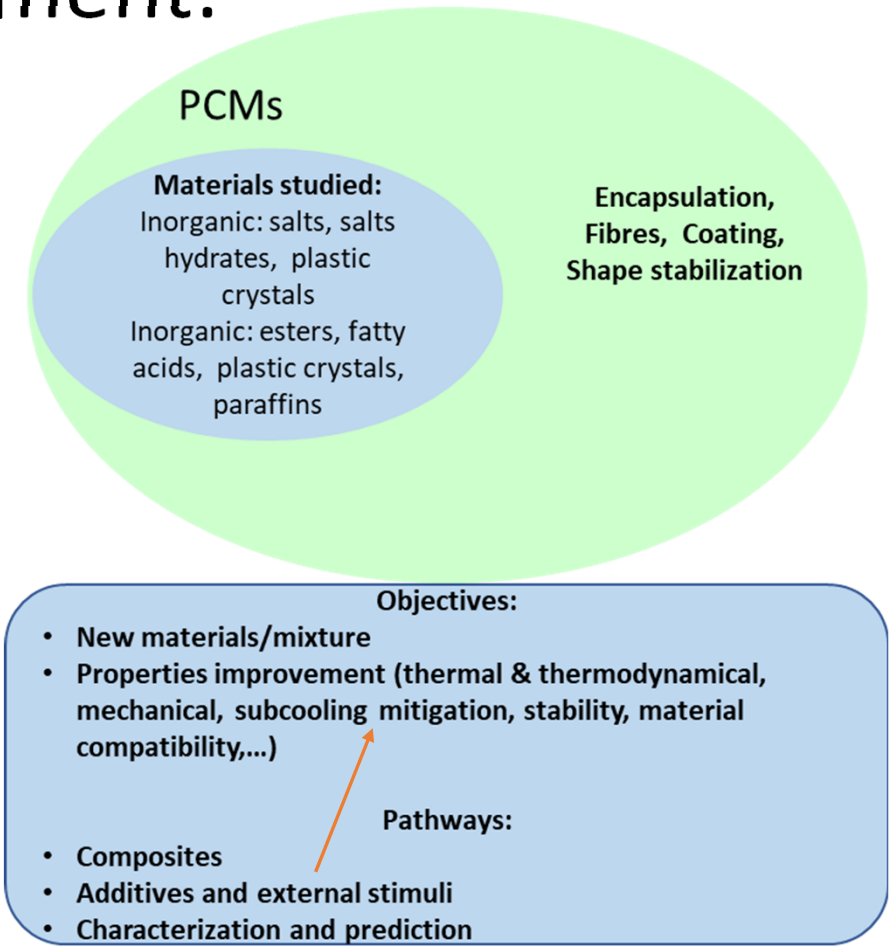
Objectives:

- From understanding of phenomena to demonstration scale
- New materials & processes
- Properties improvement (storage capacity, structural stability, heat & mass transfers, mechanical,…)

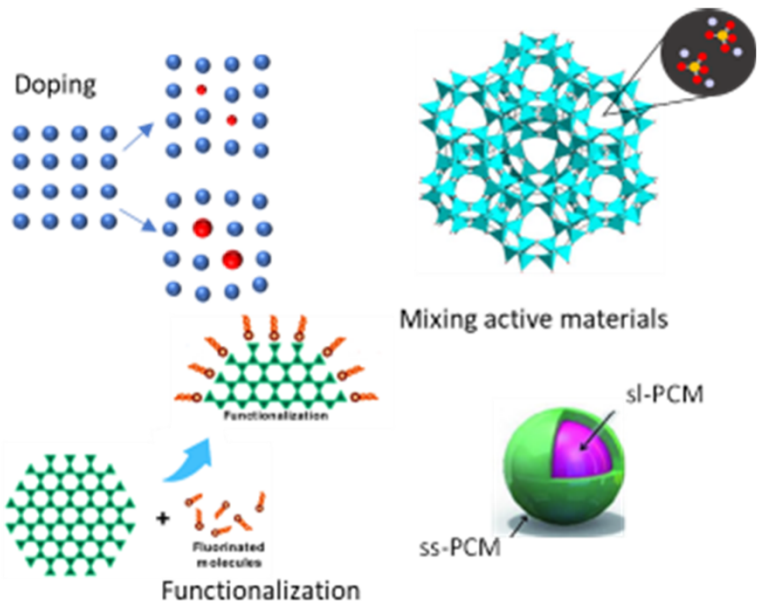
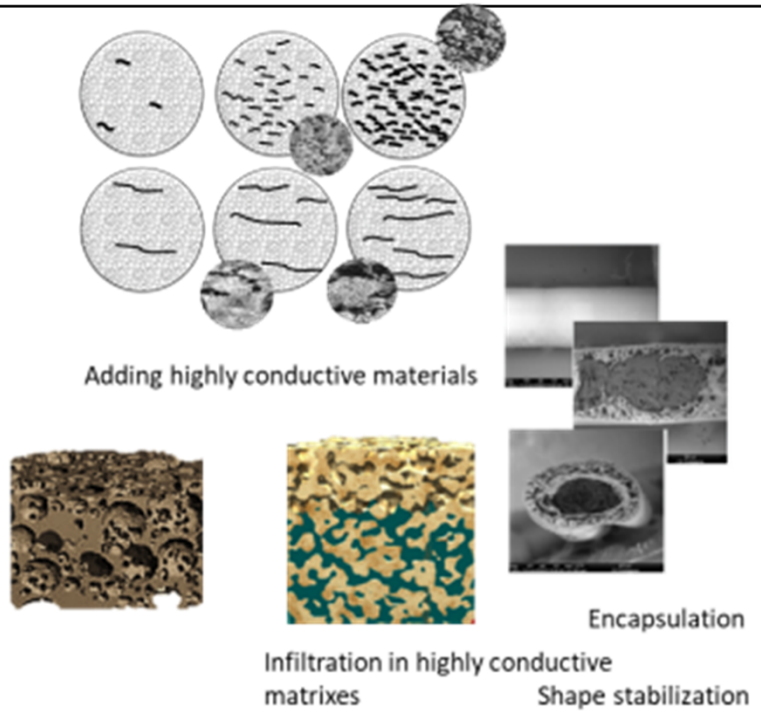
Pathways:

- Composites
- Synthesis and process
- Scale-up

Materials Development: PCM



Materials modification strategies

Tailoring energy density/temperatures	Tailoring heat and mass transfer
	

Materials modification

Outcome:

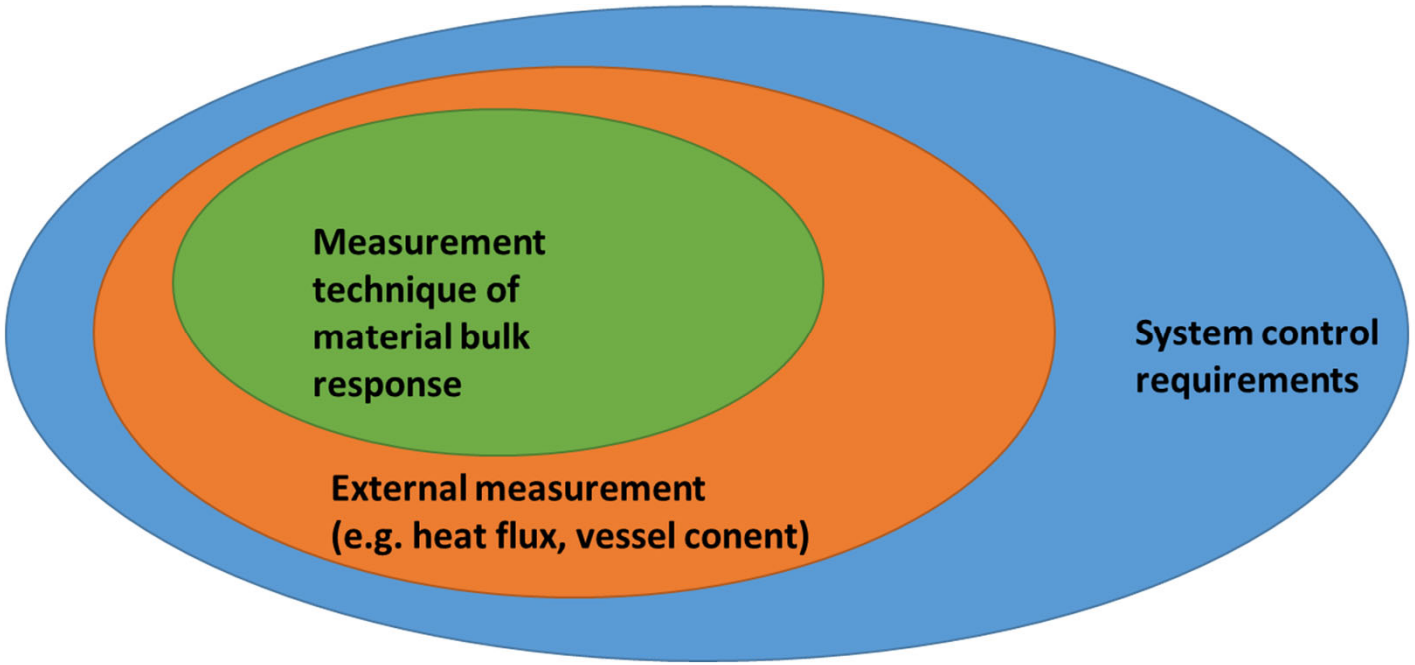
- Description of existing strategies to modify material properties
  - Published article on materials improvement case studies
- Overview of expertise on CTES material improving/optimisation

State-of-Charge Determination

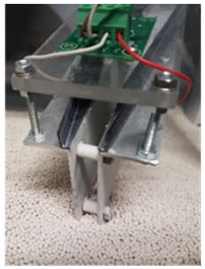
PCM and TCM

- Temperature is no direct measure for enthalpy content/SoC, especially not in bulk
- SoC determination is important for (energy) system control and for sector coupling
- Search for physical properties / measurable signals that can be connected to the SoC

State-of-Charge Determination



State-of-Charge Determination

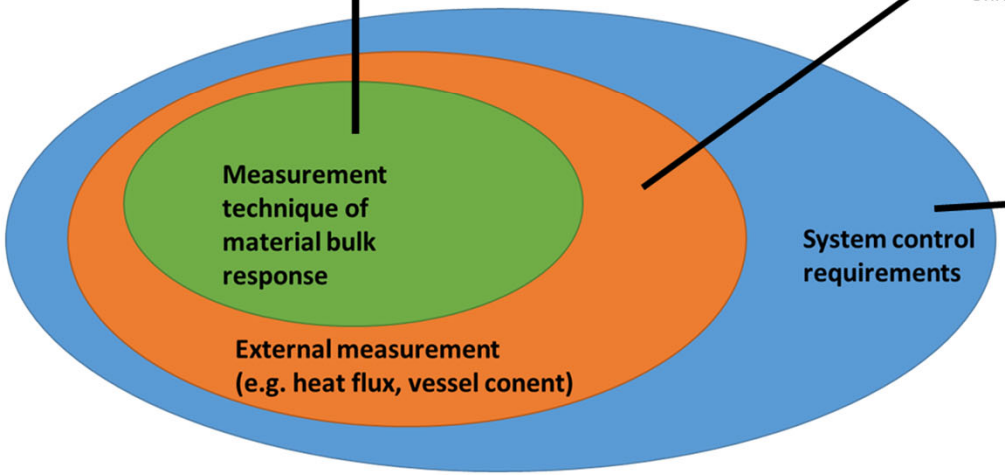


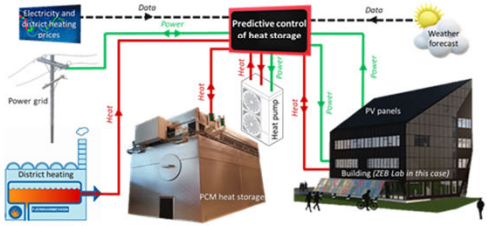
Source: FH Upper Austria

Material laboratory:
Material response with charging/ discharging can be reproduced

Source: Technical University of Denmark

Pilot testing:
Correlation of material response to heat flux
→ Calibration at test stand





Source: SINTEF; https://www.sintef.no/en/projects/2021/presav-prediktive-styringsstrategier-til-aktiv-varmelagring-i-zeb-laboratoriet/

Reliable, instantaneous SoC determination enables CTES in flexible systems

Technology Position Paper

High level information, basis for uptake and further development

- Current Status on PCM and TCM
- Potential of the technology
  - Seasonal storage of solar energy (375 TWh of annual energy savings)
  - Dishwasher (4.7 TWh annual electricity savings)
  - Distributed power-to-heat (300 TWh annual uptake)
  - Data center cooling (EU: 10 GW of demand response, 2030)
  - Thermal comfort in buildings
  - Industrial processes (1,600 TWh of fossil fuels replaced)

Actions needed

Challenge	Action needed	Action by whom
Added value to the energy system is not monetarized	Include the CTES into the total system costs and compare these to other system configurations with the same performance. Pass volatility of energy prices to the operators of CTES storage technology.	Application/system engineers Policy makers, electricity companies
Relatively high cost	Long-term market introduction support program.	International and national policy makers
Slow progress of technology development and innovation	National and international, long-term and dedicated R,D&D support programs, also aimed at basic CTES materials research. Targeted support to small and highly innovative CTES companies. Dedicated demonstration programs to monitor and evaluate performance and stepwise improve CTES performance.	International and national policy makers
Low industry involvement	Targeted demonstration and market introduction support programs to avoid 'valley of death' in development.	International and national policy makers, Industry decision makers
Thermal technologies are not seen	Increase awareness among decision makers and the broader public on the potential of compact thermal energy storage.	Industry decision makers, R&D community, professional organizations

Follow up of T67/T40

There are still remaining challenges:

- The upscaling of production technologies for TES materials.
- Affordability and sustainability of TES materials.
- What are the material requirements for novel TES application fields like flexible sector coupling and Carnot Batteries?
- How to translate performance requirements into an optimal design of components?
- Support the needs regarding TES materials and components from companies active in this field.

Planned Materials Work

- Lessons learned
  - On materials R&D and application requirements
  - Disseminate and publish best practices/lessons learned
- Material characterisation
  - Include high-temperature materials
  - Round-robin tests
- Material synthesis and production
  - Production upscaling methods → stronger commercial deployment
- TES Materials Database
  - Expansion of available material data

Planned Components Work

- Component Design
  - Design approaches
  - Component and operating parameters for appropriate design metrics
  - Feedback from practice
- State of Charge
  - Proof of concepts (TCM) and measurement techniques (PCM)
  - Catalogue of SoC determination solutions
- Applications and Case Studies
  - TES applications across sectors and temperatures
  - High-impact case studies on TES integration
  - Evaluate techno-economic and environmental performance
- Possibilities of Artificial Intelligence in TES Component Design
  - Inventory of underlying methods
  - Prerequisites, requirements, barriers, challenges

Next steps

- Draft work plans to be finalised (April 2025)
- Discussion and decision by Executive Committees of IEA Energy Storage and Solar Heating and Cooling Programmes (May/June 2025)
- Official start in July 2025
- Kick-off Meeting in October 2025

For more information: see last page.

References

❖Technology Position Paper:

https://task67.iea-shc.org/Data/Sites/1/publications/IEA_SHC_Technology_Position_Paper_Compact_Thermal_Energy_Storage_June2023.pdf

❖Article on material modifications:

https://pubs.acs.org/doi/abs/10.1021/acsaem.4c01702

❖Final Task reports available in June 2025:

https://task67.iea-shc.org/publications

and

https://iea-es.org/publications/type/final-reports/

Reactions are welcome

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