Task 67

Compact Thermal Energy Storage Materials

IEA SHC is again partnering with the IEA Energy Storage (ES) Programme to tackle storage issues. Building on earlier projects, IEA SHC and IEA ES are collaborating to push compact thermal energy storage technology developments and accelerate the market introduction of these technologies. To achieve these goals requires a diverse international team of experts from materials research, components development and system integration, and industry and research organizations.

The objectives of SHC Task 67/ES Task 40 on Compact Thermal Energy Storage Materials are fourfold: 1) better understand the factors that influence the storage density and the performance degradation of Compact Thermal Energy Storage (CTES) materials, 2) characterize these materials in a reliable and reproducible manner, 3) develop methods to determine the State of Charge of a CTES effectively, and 4) increase the knowledge base on how to design optimized heat exchangers and reactors for CTES technologies.

To meet these objectives, the project participants will work in five focused areas:

- Subtask A: Material Characterization and Database
- Subtask B: CTES (Compact Thermal Energy Storage) Material Improvement
- Subtask C: State of Charge – SoC Determination
- Subtask D: Stability of PCM (Phase Change Material) and TCM (Thermochemical Material)
- Subtask E: Effective Component Performance with Innovative Materials

As Wim van Helden, the SHC Task Manager, notes, "A number of improved CTES materials were developed in the first joint SHC and ES Task, SHC Task 58/ES Task 33. In this new collaborative Task, we will take the developments a step further by gaining more knowledge on the mechanisms behind materials performance to increase our possibilities to enhance CTES materials in a targeted and more efficient manner."

Since the start of the Task in October 2021, the experts have been working hard. Below are some of the activities and findings of the first two Subtasks.

Material Characterization and Database

The joint Task's work on material characterization and a database fall under the work of Subtask A. This Subtask is dedicated to standardized measurement procedures for thermal energy storage materials and further expanding and maintaining the existing material and knowledge database available here, https://thermalmaterials.org/.

In the prior joint SHC Task 58/ES Task 33 on Material & Components for Thermal Energy Storage, new materials were found and developed in research projects by the participating partners. And measurement procedures were advanced to identify these materials' main physical or chemical parameters. Some applied measurement procedures have since been validated, while others are just at the beginning of the process. More details on

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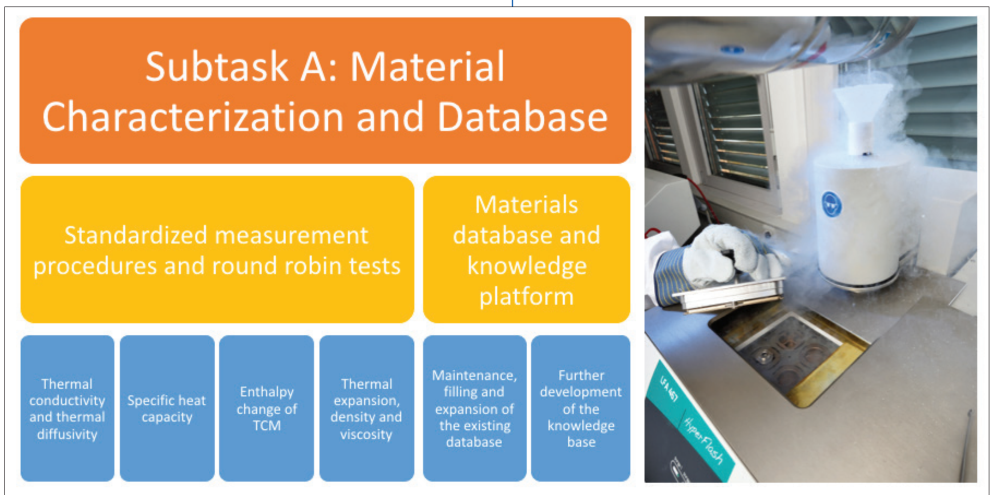
these procedures can be found in the SHC Task 58 report, Material and Component Development for Thermal Energy Storage: TCM measuring procedures and testing under application conditions.

In this current Task, participants will carry on the previous work to expand the database with other classes of materials, especially thermochemical storage materials, and to encourage its use by experts working in the field.

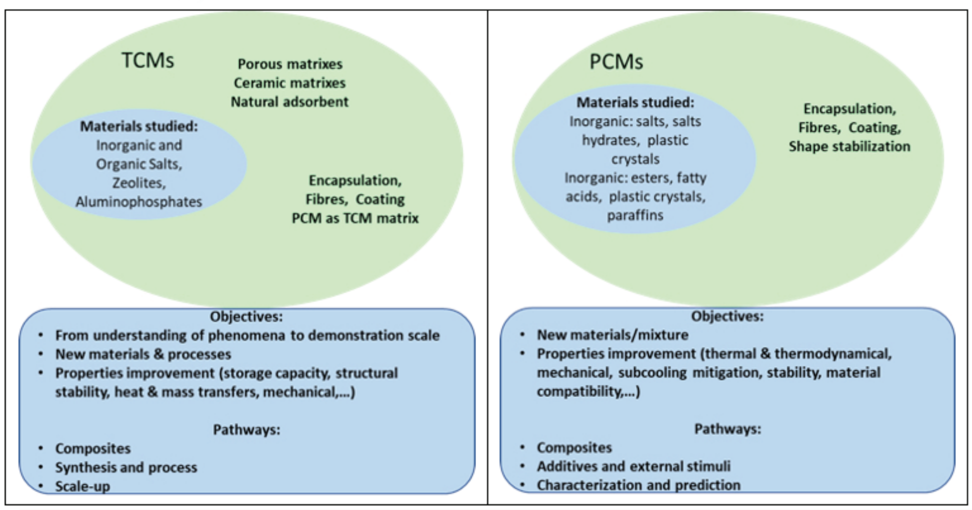
And measurement activities will continue with standardized measurement procedures further developed based on round robin tests on thermal conductivity and specific heat capacity, enthalpy change due to sorption/chemical reactions, thermal expansion, and viscosity. Thirty-seven organizations from 14 countries have recently started their round-robin measuring campaigns (see Figure 1).



▲ **Figure 1. Work structure of Subtask A.**

CTES Material Improvement

The work in Subtask B focuses on improving compact thermal energy storage materials (tailored materials and composites) with the primary objective of identifying proper strategies to tune the reactivity of CTES materials, thus improving their properties and final performances. It is generally known that TES materials must fulfill several requirements to be considered good candidates for the targeted applications. For this reason, key parameters need to be improved, including energy storage density, kinetics, thermal conductivity, mechanical properties, cycling behavior, compatibility, and ability to be engineered into a practical system. This implies identifying ad-hoc strategies to design advanced functional materials to substantially impact (simplify) the TES system design and cost.



▲ **Figure 2. Example of the materials covered in Subtask B.**

The materials targeted in Subtask B are PCMs, focusing both on solid-liquid and solid-solid transitions and composites or shape-stabilized derived materials, and TCMs, focusing both on sorption processes (ad- and absorption) and chemical reactions (mainly gas-solid systems). Figure 2 shows an example of the materials to be studied and the paths for improvement.

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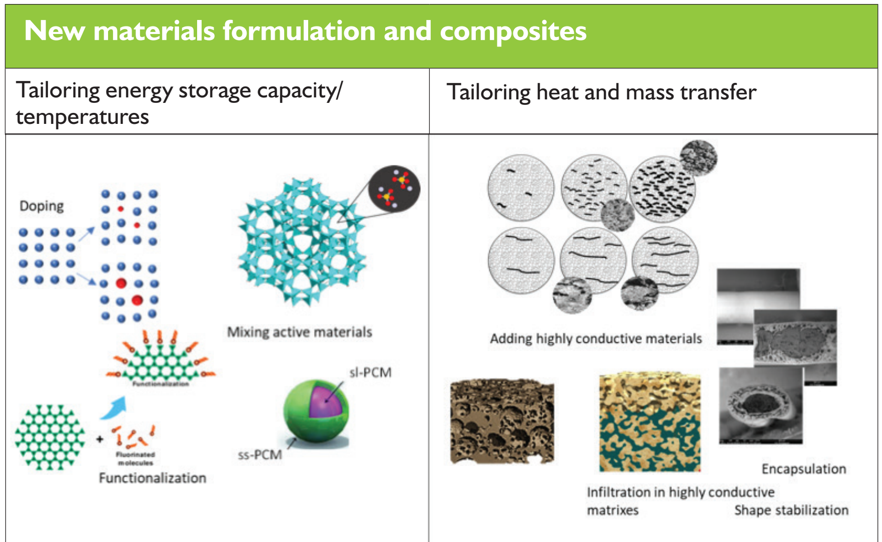
Figure 3 shows how the research includes tailoring energy storage capacity/working temperature through crystal structure modification, functionalization, and nanostructured materials. New Composites are designed by mixing active and porous inorganic and organic materials. Enhancing heat and mass transport properties by 1) adding highly conductive materials, 2) infiltration in highly conductive matrixes, and 3) material with high thermal conductivity (foam/fibers). Improving integration into the application using 1) shape-stabilization, 2) granulation with active and inactive binders, 3) coatings, and 4) monoliths.



▲ **Figure 3. Materials modification strategies studied in Subtask B.**

In the Subtask, the expertise and research work of more than 20 institutions and experts in the thermal energy storage field is being shared to define common guidelines (including strategies for material improvement and definition of KPIs) in close collaboration with the other Subtasks of SHC Task 67/ES Task 40.

Following this strategy, the preliminary work has included building a map of all the materials studied by the experts involved, including 1) the types of materials, 2) the improving strategies, 3) the main goals of the research, and 4) the application addressed. Experts have also identified synergies between the different research entities. Working groups will take the next steps, which include defining KPIs and preparing (by the end of 2022) a joint document on guidelines for materials improvement summarizing the most relevant findings of the experts participating in Subtask B in connection with the scientific community work.

To learn more about SHC Task 67, visit the Task webpage https://task67.iea-shc.org. If you have questions, contact the SHC Task Manager, Wim van Helden at w.vanhelden@aee.at.