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IEA SHC Task 42 / ECES Annex 29

Compact thermal energy storage

Matthias Rommel[a*], Andreas Hauer[b], Wim van Helden[c]

[a]SPF Institute for Solar Technology – University of Applied Sciences HSR, Oberseestr. 10, 8640 Rapperswil, Switzerland
[b]ZAE Bayern, Walther-Meißner-Str. 85748 Garching, Germany
[c]AEE INTEC, Feldgasse 19, 8200 Gleisdorf, Austria

Abstract

The IEA SHC Task 42 / ECES Annex 29 concerns thermal energy storage technologies based on Phase Change Materials (PCM) and Thermo-Chemical Materials (TCM) as well as liquid and solid sorption processes. Sensible heat storages such as hot water tanks were not investigated in the task but served as benchmarks with respect to technical and economical evaluations. This IEA task is a joint task of the IEA Solar Heating and Cooling (SHC) program and the IEA Energy Conservation through Energy Storage (ECES) program and will run up to end of December 2015. This paper gives an overview on the topics and main results of IEA SHC Task 42 / ECES Annex 29.

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1. Introduction

About half of the world’s final energy demand is used for heating and cooling purposes. Therefore, technologies that can efficiently and effectively store heat are of key importance. They assist to increase the share of sustainable heat sources and improve the efficiency of thermal systems. Recent research results and technical developments show that thermal storage technologies will become even more important with increased use of Smart Grid developments.

Thermal energy storage technologies are needed to match the variable supply of sustainable heat and to optimize the performance of thermal systems. Innovative compact thermal energy storage technologies are based on the physical principles and properties of phase change materials (PCM) and on thermochemical materials (TCM). These

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materials offer the technical opportunities to store heat in a more dense form and with fewer losses than conventional, sensible heat storage technologies such as hot water storage tanks.

Some important application areas of compact thermal energy storage technologies are:

- seasonal storage of solar energy,
- "waste heat" recovery in industrial processes,
- temperature control in buildings,
- improved efficiency in the operation of Smart Grids, district heating- and low-temperature distribution networks using (micro)cogeneration plants, solar thermal collector systems and heat pumps, and
- thermal storage technologies that assist in the heat management of energy systems for hybrid and electric vehicles and transport systems.

The technology of compact heat storage systems is still under development. PCM products are already on the market for a number of niche applications. PCM is applied for temperature control in buildings and for transportation of vulnerable goods, such as medical items, food, etc. Although a number of TCMs exist (zeolites, salt hydrates and composite materials), their application in storage systems still needs more R&D work, especially with regard to process engineering.

2. Task description, task objectives and scope of the task

The objective of this joint Task was to develop advanced materials for compact storage systems, suitable not only for solar thermal systems, but also for other renewable heating and cooling applications such as solar cooling, micro-cogeneration, biomass, or heat pumps. The Task covered phase change materials (PCMs), thermochemical materials (TCMs), and composite materials and nanostructures. It included activities on material development, analysis, and engineering, numerical modeling of materials and systems, development of storage components and systems, and development of standards and test methods.

The overall goal of this task was to develop advanced materials and systems for an improved performance of thermal energy storage. This goal can be subdivided into eight specific objectives:

- to identify material requirements for relevant applications, by means of numerical simulation of currently known storage technologies, using the simulation modules developed e.g. in Phase I.
- to identify, design and develop new materials and composites for compact thermal energy storage,
- to develop measuring and testing procedures to characterize new storage materials reliably and reproducibly,
- to improve the performance, stability, and cost-effectiveness of new storage materials,
- to develop multi-scale numerical models, describing and predicting the performance of new materials in thermal storage systems, and to compare them to conventional storage systems,
- to develop and demonstrate novel compact thermal energy storage systems employing the advanced materials,
- to assess the impact of new materials on the performance of thermal energy storage in the different applications considered, and
- to disseminate the knowledge and experience acquired in this task.
- to develop an approach for the economic evaluation of compact thermal energy storage systems.

This task dealt with advanced materials for latent and chemical thermal energy storage, and excluded materials related to sensible heat storage. However, the latter category was used as reference. The task dealt with these advanced materials on three different scales:

- material scale, focused on the behaviour of materials from the molecular to the ‘few particles’ scale, including e.g. material synthesis, micro-scale mass transport, and sorption reactions;
- bulk scale, focused on bulk behaviour of materials and the performance of the storage subsystem, including e.g. heat, mass, and vapour transport, wall-wall and wall-material interactions, and reactor design;
- system scale, focused on the performance of a storage within a heating or cooling system, including e.g. economical feasibility studies, case studies, and system tests.

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