Advanced materials for compact thermal energy storage: a new Joint IEA SHC/ECES Task

M. Bakker[1*], W.G.J. van Helden[1], and A. Hauer[2]

[1] ECN, Energy Research Centre of the Netherlands, P.O. Box 1, 1755 ZG Petten, The Netherlands

[2] ZAE Bayern, Walther-Meissner-Strasse 6, D-85748 Garching, Germany

[*] Corresponding Author, *m.bakker@ecn.nl*

Abstract

A new IEA SHC/ECES Joint Task will be started on January 1, 2009. The objective of this new task, designated SHC Task 42 and ECES Annex 24, is to develop advanced materials for compact thermal energy storage, which can be used for renewable heating and cooling as well as for energy conservation. The task focuses on thermochemical materials, including sorption and composite materials, as well as on phase change materials, and includes work on material engineering and development, characterisation, numerical modelling, demonstration, and dissemination.

Keywords: thermal storage materials, renewable heating and cooling.

Background

Thermal energy storage is an important technology for renewable energy systems. By improving the effectiveness of thermal storage, the effectiveness of all renewable energy technologies that supply heat can be improved.

Particularly for solar thermal systems, thermal energy storage is essential. To reach high solar fractions, it is necessary to store heat (or cold) efficiently for longer periods of time. Until now, no cost-effective compact storage technologies are available to do this. For high solar fraction systems, hot water stores are expensive and require very large volumes of space. Alternative storage technologies, such as phase change materials (PCMs) and thermochemical materials (TCMs) are available on a laboratory scale. However, more research and development is needed before these technologies can be developed into commercial solutions.

In several IEA annexes, both ongoing and completed, it was concluded that materials are the main bottleneck for finding effective solutions for compact thermal energy storage, and that there is a need for new storage materials with a higher specific energy storage density and lower material cost.

Around the world, several groups are working on either thermal energy storage materials or applications. However, these activities are not sufficiently linked. The current activities are either limited to specific applications, or to specific materials. What is needed, and what can be provided by this new task, is a way to bring the ongoing work on materials and applications together.

Objective and scope

The objective of this international collaboration is to develop advanced materials for compact storage systems. The systems will store thermal energy for renewable heating and cooling or for energy conservation.

The objective can be subdivided into six primary goals:

- to identify, develop, and test advanced materials for compact storage,
- to design and develop new materials or composites,
- to develop measuring and testing procedures to characterise these new materials reliably and reproducibly,
- to perform pre-standardisation work for advanced thermal energy storages,
- to develop and demonstrate novel compact thermal energy storage systems employing the advanced materials, and
- to disseminate the gained knowledge.

Because seasonal storage of solar heat is the main application for thermal energy storage, this field will have the focus of this task. However, other applications are also very important, including applications in both renewable energy and energy conservation technologies. Because of this, and because materials research is not and can not be limited to one application only, this task will not focus on only one application area. Other applications in renewable energy and energy conservation-such as solar cooling, micro-cogeneration, biomass, or heat pumps-will also be taken into account.

In terms of classes of materials, this task will be focused around three main classes:

- phase change materials, including micro- and macro-encapsulation and slurries,
- thermochemical materials, including sorption, and
- composite materials and nanostructures.

The latter category includes for instance the combination between zeolites and silicagels, and materials where the molecular and crystalline structure are engineered in detail. Production technologies, the ability to produce advanced materials on a large scale at reasonable costs, is an important aspect in all of these classes.

Main activities

The task will be organised around the following main activities:

- material engineering: analysis and engineering of advanced materials, synthesis of new materials and composites, and materials characterisation and testing;
- numerical modelling: numerical modelling of materials, including molecular interactions, mass and heat transport phenomena, and bulk behaviour;
- components and systems: development, numerical modelling, and testing of (prototypes of) thermal storage components and systems that use the materials developed in the other activities.

Collaboration

The main challenge for this task is to bring together material experts and application experts (particularly solar applications, given the primary scope of the task). The active participation of both groups of experts is essential for this task. However, these groups are traditionally organised in different Implementing Agreements. ECES, Energy Conservation through Energy Storage, has a strong tradition in material research, while SHC, Solar Heating and Cooling, has a strong tradition in solar applications.

Because of the particular nature of this task, a collaboration between these two Implementing Agreements is essential. Hence, this task will take the form of a Joint Task between these Implementing Agreements.

Progress

On October 5, 2007, a first expert meeting was held in Zürich, Switzerland, followed by a Task Defintion Workshop in Petten, The Netherlands, on April 10–11, 2008. Both meetings were very well attended, not only by researchers, but also by representatives of European industries, both large and small. Based on these meetings, the outline of the new task's objective, scope, and main activities were defined. In a subsequent expert meeting in Bad Tölz, Germany, on June 4-6, 2008, the topics of the task were discussed in more detail.

One of the conclusions of these meetings wass that the main value in this task is to actively combine the knowledge of experts from materials science as well as from solar/renewable heating and energy conservation. Hence, a strong co-operation with other IEA Implementing Agreements is essential to the success of the task, as already mentioned above. Another noteworthy conclusion of the meeting was the strong interest of industry in this task: the industry representatives at the meeting all agreed on the importance of the development of new storage materials.

In their respective ExCo meetings in May and June 2008, the new task was officially approved by both the SHC and ECES Executive Committees. The task will be designated as Task 42 in SHC, and as Annex 24 in ECES. Both ExCos were very positive on the scope and topic of this task. Wim van Helden of ECN, the Netherlands, and Andreas Hauer of ZAE Bayern, Germany, were appointed as Operating Agents.

The official starting date for this four-year task is January 1, 2009. Although four years is relatively long compared to other tasks in either SHC or ECES, this is warranted by the fundamental nature of the work in this task. Because the work on advanced storage materials is still in a very fundamental stage, the trajectory towards applications is still relatively long. It takes several years to identify, characterise and optimise the right materials or composites, and again to develop the reactors, proof-of-principles, and prototypes of the advanced storages made of these materials.

Join the task

Experts from industries and research organisations worldwide, that are active in this field, are cordially invited to join this new task. If you are interested, please contact the authors of this paper or your national ECES or SHC ExCo member.

More information on this task can be found on the temporary task website at *www.ecn.nl/ieamaterials*.