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Swiss Federal Office of Energy SFOE
Energy Research

Final report

IEA-SHC Task 42 Operating Agent

(for the period from 1.1.2014 to 31.3.2016)

Figure: Screenshot from homepage http://task42.iea-shc.org/

INSTITUT FÜR SOLARTECHNIK

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SFOE contract number: SI/501027-01

The author of this report bears the entire responsibility for the content and for the conclusions drawn therefrom.

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Zusammenfassung

Die Position des Operating Agent des IEA SHC Tasks 42 “Compact Thermal Energy Storage: Material Development for System Integration” musste für die Zeit vom 1.1.2014 bis zum Ende des Tasks am 31.12.2016 neu besetzt werden. Der IEA SHC Task 42 war erfolgreich in Phase 1 (1.1.2009 bis 31.12.2012 von Dr. Wim Van Helden (NL) geleitet worden. Er war auch der Operating Agent der Phase 2 bis zum 31.12.2013.

Prof. Matthias Rommel übernahm von Dr. Wim van Helden die Position des Operating Agent des Tasks 42 für die Zeit vom 1.1.2014 bis zum 31.3.2016. Dementsprechend waren die Ziele des Projekts:

- Koordination und Leitung des IEA SHC Task 42 “Compact Thermal Energy Storage: Material Development for System Integration” als Operating Agent
- Organisation und Leitung der Experten Treffen des IEA SHC Task 42
- Berichterstattung über die Task-Aktivitäten wie sie für die ExCo-Treffen des IEA SHC benötigt werden
- Zusammenfassung der Ergebnisse des Tasks für die regelmässigen Publikationen wie Jahresbericht und Newsletters, die vom ExCo Sekretariat des IEA SHC veröffentlicht werden
- Abschluss des Tasks durch Organisation aller Präsentationen und Veröffentlichungen wie sie auf der SHC Konferenz in Istanbul, 2-4 Dezember 2015 präsentiert wurden.

Alle Projektziele wurden erreicht. Der IEA SHC Task 42 wurde erfolgreich zum 31.12.2015 abgeschlossen. Alle notwendigen Dokumente, die für das ExCo des IEA SHC benötigt wurden, wurden zeitgerecht geliefert und von ihm genehmigt. Dies betrifft auch die Dokumente, die bis 31.3.2016 vom ExCo benötigt wurden zum Abschluss des Task 42.

Die Ergebnisse des IEA SHC Task 42 / IEA ECES Annex 29 sind zusammengefasst erhältlich unter http://task42.iea-shc.org/data/sites/1/publications/Task42-Annex-29-Position-Paper-and-All-Final-Deliverable-Papers.pdf

Das Position Paper des IEA SHC Task 42 ist veröffentlicht unter: https://www.iea-shc.org/data/sites/1/publications/IEA-SHC-Compact-Thermal-Storage-Position-Paper.pdf

Résumé

Un remplacement a été nécessaire pour le poste d’agent d’exécution dans le cadre de la tâche 42 de l’IEA SHC « stockage compact d’énergie – développement pour une intégration aux systèmes » entre le 01.01.2014 et le 31.12.22016 (fin de la tâche). La tâche 42 de l’IEA SHC a été gérée avec succès par Dr. Wim van Helden (NL) durant sa première phase (du 01.01.2009 au 31.12.2012). Ce dernier a également tenu la fonction d’agent d’exécution durant le début de la seconde phase (jusqu’au 31.12.2013).

Prof. Matthias Rommel a assuré le remplacement du Dr. Wim van Helden en tant qu’agent d’exécution entre le 01.01.2014 et le 31.03.2016. De fait, les tâches principales du projet étaient :

- Coordination et direction en tant qu’agent d’exécution de la tâche 42 de l’IEA SHC « stockage compact d’énergie – développement pour une intégration aux systèmes »
- Organisation des réunions et modération des débats entre experts au cours de la tâche 42 de l’IEA SHC
- Comptes rendus sur les activités menées dans le cadre de la tâche 42 comme requis par le directoire de l’IEA SHC

- Résumé des résultats de la tâche 42 comme requis par le directoire de l'IEA SHC
- parachèvement de la tâche (organisation de toutes les présentations et articles présentés lors de la conférence SHC à Istanbul, du 2 au 4 Décembre 2015).

Tous les objectifs du projet ont été atteints. La tâche 42 de l'IEA SHC a été finalisée avec succès le 31.12.2015. Tous les documents requis par le directoire ont été délivrés et approuvés, incluant également les documents demandés début 2016 par le directoire pour son rapport de clôture de la tâche 42.

Les résultats de la tâche 42 de l'IEA SHC sont résumés à l'adresse: http://task42.iea-shc.org/data/sites/1/publications/Task42-Annex-29-Position-Paper-and-All-Final-Deliverable-Papers.pdf

Le document de synthèse de la tâche 42 de l'IEA SHC est publié à l'adresse: https://www.iea-shc.org/data/sites/1/publications/IEA-SHC-Compact-Thermal-Storage-Position-Paper.pdf

Summary

The position of the Operating Agent of IEA-SHC Task 42 "Compact Thermal Energy Storage: Material Development for System Integration" had to be replaced for the time from 1.1.2014 to the end of the Task 31.12.2016. The IEA SHC Task 42 was operated successfully in phase 1 (1.1.2009 to 31.12.2012) by Dr. Wim van Helden (NL). He also acted as OA for the first part of phase 2 up to 31.12.2013.

Prof. Matthias Rommel took over from Dr. Wim van Helden and acted as Operating Agent of the Task from 1.1.2014 up to 31.3.2016. Therefore, the main goals of the project were:

- Coordination and leadership in the position of the OA of IEA-SHC Task 42 "Compact Thermal Energy Storage: Material Development for System Integration"
- Organizing and conducting the experts meetings of IEA SHC Task 42
- Reporting on the Task activities as required for the ExCo meetings of IEA SHC
- Summarizing the Task results for the regular publications such as annual report and newsletters required by the ExCo secretariat of IEA SHC
- Finalization of the Task by organizing all presentations and papers presented at the SHC conference in Istanbul, 2-4 December 2015

All project goals were achieved. The IEA SHC Task 42 was successfully finished 31.12.2015. All documents required by the ExCo of IEA SHC were delivered and approved. This includes also all documents that were required in the beginning of 2016 by the ExCo for its reports to finalize Task 42.

The results of IEA SHC Task 42 / IEA ECES Annex 29 are summarized in: http://task42.iea-shc.org/data/sites/1/publications/Task42-Annex-29-Position-Paper-and-All-Final-Deliverable-Papers.pdf

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Contents

List of abbreviations

DSC	Differential Scanning Calorimetry
ECES	Energy Conservation through Energy Storage Programme of the IEA
ExCo	Executive Committee
IEA	International Energy Agency
OA	Operating Agent
PCM	Phase Change Material
SHC	Solar Heating and Cooling Programme of the IEA
TCM	Thermo-Chemical Material
TES	Thermal Energy Storage

1. Project goals

The position of the Operating Agent of IEA-SHC Task 42 “Compact Thermal Energy Storage: Material Development for System Integration” had to be replaced for the time from 1.1.2014 to the end of the Task 31.12.2016. The IEA SHC Task 42 was operated successfully in phase 1 (1.1.2009 to 31.12.2012) by Dr. Wim van Helden (NL). He also acted as OA for the first part of phase 2 up to 31.12.2013.
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- Reporting on the Task activities as required by the ExCo of IEA SHC
- Summarizing the Task results for publications required by the ExCo of IEA SHC
- Finalization of the Task by organizing all presentations and papers presented at the SHC conference in Istanbul, 2-4 December 2015

2. Completed tasks and achieved results

All project goals mentioned above were achieved. The IEA SHC Task 42 was successfully finished 31.12.2015. All documents required by the ExCo of IEA SHC were delivered and approved. This includes also all documents that were required in the beginning of 2016 by the ExCo for its reports to finalize Task 42.

3. National cooperation

There was no national cooperation necessary with respect to the responsibility as Operating Agent. Of course, there was a regular exchange of information on all matters of the Task with the Swiss ExCo members Andreas Eckmanns and Jean-Christophe Hadorn, especially in preparation of the half-yearly ExCo meetings and during these meetings.

With respect to scientific and technical contributions from Switzerland to the Task 42 (which is actually not the topic of the contract which is concerned by this report) there was a collaboration with the experts Benjamin Fumey and Robert Weber from EMPA and Dr. Paul Gantenbein and Dr. Xavier Daguenet from SPF. That was due to the fact that EMPA and SPF both contributed to the long term storage activities of Task 42 by reporting results from an EU-funded Project “COMTES” and different BFE-funded projects.

4. International cooperation

With respect to the position of the Operating Agent of IEA SHC Task 42 there was a strong cooperation with Dr. Wim van Helden (NL) form whom I took over. As IEA SHC Task 42 was organized as a Joint Task with IEA-ECES Annex 29, there was also a strong cooperation with the Operating Agent of IEA-ECES Annex 29, Dr. Andreas Hauer (ZAE Bayern, Germany).

Naturally, there was also a strong and successful cooperation with the Subtask Leaders:

Subtask A1: Dr. Alenka Ristic, Slovania

Subtask A2: Stefan Gschwander, Germany

Subtask A3: Prof. Dr. Camilo Rindt, The Netherlands,

Subtask B: Prof. Motoi Yamaha, Japan,

Subtask C: Christoph Rathgeber, Germany.

The following table gives an overview on the international participation in the IEA SHC Task 42 on the experts level:

Country	Number of Research Institutes	Number of Universities	Number of Companies
Austria	3	3	1
Australia	1	1	
Belgium	1	2	
Switzerland	2	3	1
Germany	5	6	2
Denmark		1	
Spain	4	4	1
France	2	5	1
Italy		1	
Japan	1	4	
The Netherlands	2	1	1
Sweden		2	
Slovenia	1	1	
Turkey		2	
United Kingdom		6	1

Over the entire term of the Task a total of 6 Expert meetings were held. The number of participants varied between 35 and 49 which is relatively high compared with other IEA SHC tasks.

Meeting #	Date	Location	Number of Participants
EM9	15-17 April, 2013	Freiburg, Germany	47
EM10	2-4 October, 2013	Ljubljana, Slovenia	35
EM11	28-30 April, 2014	Lyon, France	43
EM12	8-10 October 2014	Nagoya, Japan	36
EM13	9-11 February 2015	Vienna, Austria	49
EM14	5-7 October 2015	Zaragoza, Spain	47

5. Results achieved and key accomplishments

The following is a brief summary on the key accomplishments of each single work activity within the Subtasks.

Working Group A1: Materials Engineering and Processing

In the scope of Task 42 from 2013 to 2015 more than 20 institutions from more than 12 countries were taking part in working group A1: “Engineering and processing of TES materials”.

New and improved materials for compact TES:

During this period different **new and improved PCMs** were investigated: eutectic binary mixtures of sugar alcohols, low cost paraffin, cement mortar + microencapsulated PCM, polystyrene (PS)/n-heptadecane micro/nano-capsules, inorganic PCM ternary mixtures, PEG 10,000, microencapsulated n-octadecane, binary mixtures of linear alkanes and saturated fatty acids, new sugar alcohol eutectic mixtures and others. Also the following **new and improved TCM-materials** were synthesized and investigated: binder-free zeolite Y, activated carbon, composites of salt hydrates within porous matrices, etc.

Promising PCMs for different temperature ranges and applications:

- New PCMs with potential for **solar thermal regulation of buildings and food storag**e containers are polymethylmethacrylate(PMMA)/capric-stearic eutectic mixture (C-SEM) micro/nano capsules can be integrated with conventional building materials polystyrene (PS)/n-heptadecane micro/nano-capsules.
- With respect to **solar heating and domestic hot water applications** new binary mixtures of sugar alcohols comprising erythritol, sorbitol and xylitol were studied.
- **For cold storage** new binary eutectic mixtures of salt hydrate-based PCMs were prepared.

Material properties investigated and the role of material containers:

Material`s properties (nontoxicity, density, solubility, specific heat, thermal conductivity, enthalpy, viscosity, phase change, degree of subcooling, cycling stability, thermal stability, etc.) structures (for example: decanoic acid/chitosan-gelatine microcomposite), compositions (salt hydrates + porous carbon or silica, paraffin wax + multi-walled carbon nanotubes, sugar alcohols+ porous carbon etc.) and the role of material containers (e.g. stainless steel 316 can be used for storing the investigated inorganic PCM and TCM) were determined for latent, chemical and sorption heat storage.

Methods for TES-materials processing:

Different optimal methods for materials processing were found, like **microencapsulation** (caprylic acid/chitosan-gelatine, sugar alcohols), micro/nanoencapsulation (capric, lauric and myristic acids with polystyrene shell), **phase change slurries** (n-octadecane-water emulsion) for PCMs and new combinations of composite materials (PCMs and TCMs). TCM composite were prepared by **wet impregnation** ($MgCl_2$/porous carbon or vermiculite, APO/carbon) and **incipient wetness impregnation** ($CaCl_2$/porous silica). **Improvements of TCM`s properties** were achieved by the oxidation treatment of activated carbon and composites of $CaCl_2$/porous silica (hydrophilicity), dealumination of zeolite Y (lower regeneration temperature), preparation of APO/carbon or APO coating on metal plate (thermal conductivity), mixing $MgCl_2$ and $CaCl_2$ (preservation of cycling stability), etc.

Two general remarks:

- The research was mainly conducted in the field of PCMs, while only few research projects were performed in the field of thermochemical materials.
- It can be observed that mainly engineers/physicists were involved in the research of materials and there were very few chemists. It is recommended that in the future, experts of material science and chemists from the fields of organic and inorganic chemistry should be more involved in order to strengthen the development of TES materials.

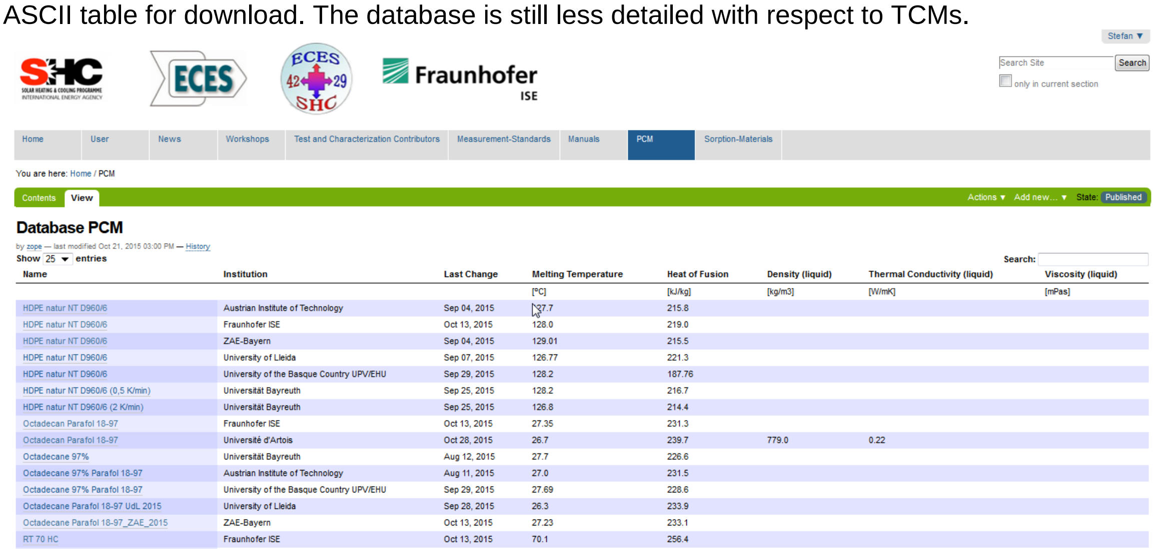
Working Group A2: Test and Characterization

Seven scientific institutions worked on the development of measurement standards for PCM characterization within the framework of IEA SHC Task 42 / ECES Annex 29 (Task 4229). The first and main focus was set on characterization of PCMs by DSC measurements, but also the T-History method as well as methods to determine the thermal conductivity and flow behavior were investigated. The second focus was set on the development and establishment of a database for PCM, TCM and sorption materials.

The **newly developed procedure for the DSC measurement of PCMs** is available at http://task42.iea-shc.org/data/sites/1/publications/Task4224-Standard-to-determine-the-heat-storage-capacity-of-PCM-vers150326.pdf and consists of five elements:

1. Heating and cooling rate test to determine suitable heating and cooling rates for the PCM to be measured. This is done by using the PCM to be characterized and applying heating and cooling rates starting from fast rates (e.g. 10 K/min) and slowing down the heating and cooling rates of consecutive cycles by halve the previous.
2. Calibration of the DSC by using 3 different calibration materials covering the desired temperature range (e.g. water, gallium and indium). The calibration has to be done with the determined heating rate.
3. Measurement of the empty crucible using the determined heating and cooling rates.
4. Sample measurements by applying the sample to the crucible (apply the same sample mass as for the heating rate test) using the determined heating rate. Four measurement cycles have to be applied and three samples have to be measured
5. Analysis of data: If necessary, baseline correction (displacement to zero heat flow) has to be applied. Carry out subtraction of heat flow signal measured with empty crucible from sample measurement. Final data evaluation and computation of enthalpy curves.

A database was developed and established to upload PCM data which is measured according to the new standard. It provides an overview table of all stored PCMs (see figure). By choosing a PCM all relevant measurement parameters are available (onset temperature, integration limits for the given heat of fusion, sample mass, heating rate, etc) as well as the measured data which is provided as ASCII table for download. The database is still less detailed with respect to TCMs.



Database PCM

by zope — last modified Oct 21, 2015 03:00 PM — History

Show 25 entries

Search:

Name	Institution	Last Change	Melting Temperature	Heat of Fusion	Density (liquid)	Thermal Conductivity (liquid)	Viscosity (liquid)
			[°C]	[kJ/kg]	[kg/m3]	[W/mK]	[mPas]
HDPE natur NT D960/6	Austrian Institute of Technology	Sep 04, 2015	[illegible]27.7	215.8			
HDPE natur NT D960/6	Fraunhofer ISE	Oct 13, 2015	128.0	219.0			
HDPE natur NT D960/6	ZAE-Bayern	Sep 04, 2015	129.01	215.5			
HDPE natur NT D960/6	University of Lleida	Sep 07, 2015	126.77	221.3			
HDPE natur NT D960/6	University of the Basque Country UPV/EHU	Sep 29, 2015	128.2	187.76			
HDPE natur NT D960/6 (0,5 K/min)	Universität Bayreuth	Sep 25, 2015	128.2	216.7			
HDPE natur NT D960/6 (2 K/min)	Universität Bayreuth	Sep 25, 2015	126.8	214.4			
Octadecan Parafol 18-97	Fraunhofer ISE	Oct 13, 2015	27.35	231.3			
Octadecan Parafol 18-97	Université d'Artois	Oct 28, 2015	26.7	239.7	779.0	0.22	
Octadecane 97%	Universität Bayreuth	Aug 12, 2015	27.7	226.6			
Octadecane 97% Parafol 18-97	Austrian Institute of Technology	Aug 11, 2015	27.0	231.5			
Octadecane 97% Parafol 18-97	University of the Basque Country UPV/EHU	Sep 29, 2015	27.69	228.6			
Octadecane Parafol 18-97 UdL 2015	University of Lleida	Sep 28, 2015	26.3	233.9			
Octadecane Parafol 18-97_ZAE_2015	ZAE-Bayern	Oct 13, 2015	27.23	233.1			
RT 70 HC	Fraunhofer ISE	Oct 13, 2015	70.1	256.4			

Working Group A3: Numerical Modeling

The activities within the working group A3 in the framework of IEA SHC Task 42 / ECES Annex 29 (Task 4229) related to different level modeling and simulations. As an example of activity for developing and testing numerical models to understand and optimize material behavior, the experts of the working group A3 investigated MgCl2 hydrates.

Molecular models were used to check the effect of water vapor pressure on hydrolysis and dehydration reaction. The results of the water diffusivity in the crystalline structure were further used in higher level models in the working group. This can in a later stage be used to optimize specific properties of the storage materials with respect to their usage.

From the numerical results of material and thermophysical properties of PCM storage systems, it is clear that some deviation may occur if the enthalpy function does not perfectly fit the real behavior of the material.

Firstly, this may arise if the thermophysical characterization of the PCM is not correctly conducted. Here it becomes clear that the results of the experts' work in WG A1 and A2 is of great importance for the work in WG A3. It is clear that further research work is necessary and material measurements have to be further improved so as to define reliable numerical and simulation methods.

Secondly, such a bias could also come from the degradation of the product during its lifetime, independently of the precision of the characterization method. Consequently one has either to search for very stable materials (which may be difficult) or to determine the temporal evolution of the thermophysical properties, which is solely done and should thus be also further investigated.

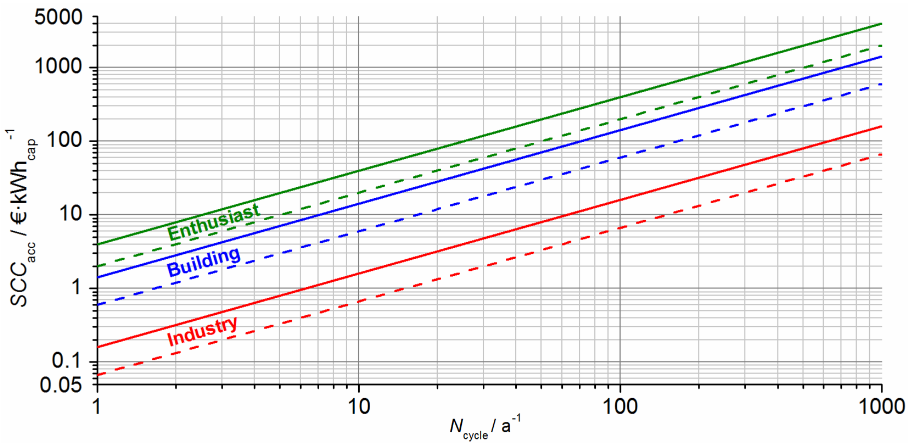
Working Group B: Applications

Within the Working Group B (Applications) of the IEA joint Task/Annex 4229, a large number of experts from more than 20 research organizations worked on applications of compact thermal energy storage technologies. Application fields are cooling, room heating/domestic hot water and thermal storage for industry. The main challenges in the development of applications are in finding an optimal connection between the storage material and the other materials, the components and the system configuration. The problems to be solved are in the area of materials compatibility, like corrosion protection, prevention of side reactions and cycling stability; in the area of component design, with

heat and mass transfer optimisaton; and in the area of system design with control strategies and cost minimisation.
Thermal storage for cooling applications is the most advanced. There are numerous examples of ice storage systems, running to get a higher system performance or to enable a shift of electricity consumption from daytime to nighttime. Challenges in these systems are the integration of novel PCMs with somewhat higher melting temperatures than water and the system optimisation in connection with electricity grids and heating networks.
Most application developments in T4229 are in the area of thermal energy storage for room heating and domestic hot water preparation. Here, there is a broad collection of storage technologies and system concepts being developed and tested. Phase change materials and thermochemical materials are applied as active material in open and closed systems.
A third field of application is in the transportation of residual or waste heat to a remote user by compact thermal storage technologies. Due to scaling effects, this application is first developed for industrial users.
In the Task, special attention was paid to the interaction between materials researchers and system engineers. A compact thermal energy storage material only has value in a certain application, and the application will imply certain design conditions on the storage material. A first step towards a better interaction is for system engineers to understand how materials researcher evaluate the properties of a storage material, and for materials experts to understand the practical implications of integrating material into a storage system. In the Task, work was done to couple the material properties to system performance, although this in most cases is far from straightforward. For sorption storage technologies, an approach was set up using four typical operating temperatures with which the operation boundary conditions are determined and the performance of a storage material in an application can be determined (see paper by Hauer et al. for SHC-2015 conference).
Given a certain application, it is necessary to have a common basis for determining the performance of different storage technologies. To this end, a design has been made of a set of Key Performance Indicators KPI's of compact thermal energy storage for seasonal storage. In future, these KPI's will be a valuable tool for comparison of different thermal storage concepts.
Solar Heating and Cooling with Absorption Chiller and Latent Heat Storage; ZAE Bayern

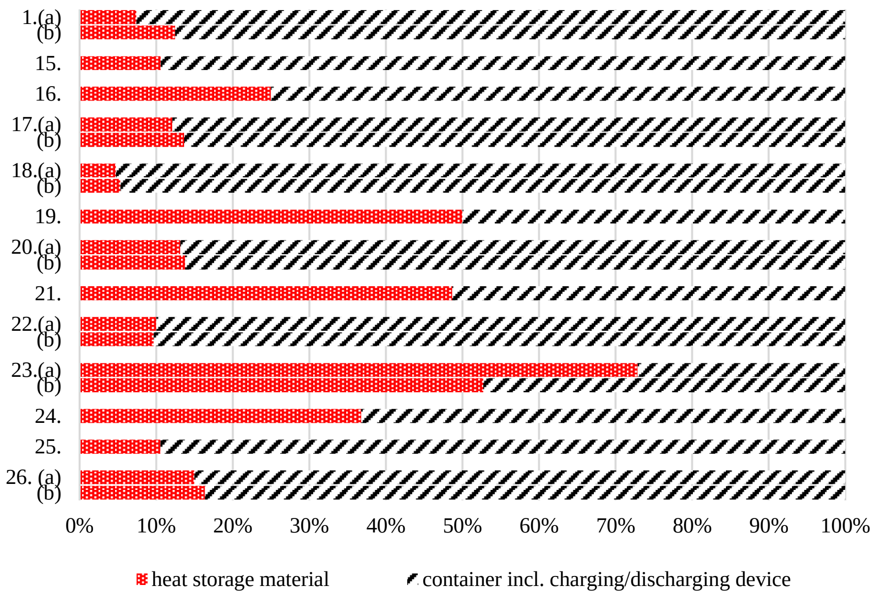
Working Group C: Theoretical Limits

Within the framework of IEA SHC Task 42 / ECES Annex 29, a tool for the economic evaluation of thermal energy storages has been developed and tested on various existing storages. On that account, the storage capacity costs, i.e. the costs per installed storage capacity, of thermal energy storages have been evaluated via a Top-down and a Bottom-up approach.
The Top-down approach follows the assumption that the costs of energy supplied by the storage should not exceed the costs of energy from the market. The maximum acceptable storage capacity costs depend on the interest rate assigned to the capital costs, the intended payback period of the user class (e.g. industry or building), the reference energy costs, and the annual number of storage cycles.



The figure above shows the maximum acceptable storage capacity costs (SCC_{acc}) as a function of storage cycles per year N_{cycle}, determined for the three user classes industry, building sector and enthusiast. A double-logarithmic scale was chosen to visualize both SCC_{acc} of long-term storages with only few cycles per year and short-term storages with several hundred cycles per year. These results indicate that, for a fixed cycle period N_{cycle}, SCC_{acc} depend on the user's economic environment. The low case of the industry sector and the high case of enthusiasts differ by a factor of about 60 in costs. Short-term storage with several hundred storage cycles per year, however, allows several hundred times higher storage costs because of the larger energy turnover.

The Bottom-up approach focuses on the realized storage capacity costs of existing storages. It has been applied to analyze the costs of 26 thermal energy storages, also including commercial water storages to check the evaluation methodology of the bottom-up approach. It has to be stressed here that the innovative storages of Task 42/Annex 29 are subject of ongoing research and by far not yet developed for application in the market. Hence, their corresponding costs are only very rough estimations. The comparison of SCC_{acc} and SCC_{real} indicates that, at present, seasonal storage is only economical using large hot water storages; other technologies require at least an order of magnitude reduction in costs. This is a very strong indication and proof that the topic of compact thermal energy storage still needs much more R&D activities, especially with respect to long term storage. It also means that the development of storage systems which allow a high annual number of storage cycles is economically favourable over seasonal storages.



In order to identify major cost drivers and, thereby, cost reduction potentials for the investigated storage systems, the composition of the investment costs has been analyzed. The figure above illustrates how the investment costs of thermal energy storages under investigation in Task 42 / Annex 29 are divided into costs of the heat storage material itself and costs of the surrounding container or reactor incl. charging/discharging device. So, the Bottom-up analysis showed that a major fraction of the investment costs of the investigated storages are not costs of the heat storage material itself but costs of the storage container or reactor (incl. charging/discharging unit). Therefore, R&D activities on cost-effective TES systems have to consider both, cost-effective heat storage materials and cost-effective storage container or reactor components.

6. Task management: Overall conclusions and recommendations

The following overall conclusions and recommendations with respect to the task management can be drawn:

1. This Task was a joint Task from the SHC program and the ECES program. Almost all experts appreciated this very much because it enlarges the possibilities for research exchange a lot and helps to bring material scientists and system engineers together. The level of scientific collaboration among the experts is very high. This concerns especially the experts from WG A1 and A2 who carried out additional workshops for the development of the DSC measurement procedure and the establishment of the materials database.
   Recommendation: It is strongly recommended that a follow-on task is again organized as a joint task in spite of the fact that the operating agents have additional organizational and reporting conditions to fulfill for their respective ExCos.
2. The structure of experts meetings proved to be good and appropriate to manage the group of experts which is quite large. We had between 35 and 49 experts participating in the different experts meetings.
   Recommendation: Keep the structure of the experts meetings in which a group of "delegated experts" meets on the last meeting day. These are mainly the Subtask leaders, OAs and some additional experts who are important for the next steps to be taken in the task. They can more effectively decide on the organizational matters of the task than the large group.
3. The research field of compact thermal storage systems lacks nationally funded projects which would help to keep track on the research aims and deliverables of the IEA-ECES Task. Many of the projects were EU-funded. This concerns especially the work of Subtask WG_B. For these projects, the deliverables and goals are defined in their research contracts with the EU and these are not necessarily completely in line with the work description, goals and deliverables of the task.
   Recommendation: Try to have more nationally funded projects from the SHC and ECES countries supporting the Task which are in line with the aims and deliverables of the Task.
4. One of the main achievements of the Task is the fact that material scientists and system engineers are working closely together and are learning from each other. This was considered to be very positive from almost all experts.
   Recommendation: From the management point of view it may be helpful to have some more parallel sessions in the experts meetings for the material scientists on the one hand and for the system engineers on the other. This will help to ensure also knowledge transfer among the material scientists and among the system engineers.

7. Evaluation 2014 to 2015 and outlook 2016

Evaluation 2014 to 2015:

The final results of IEA SHC Task 42 / IEA ECES Annex 29 are summarized in a document which is available at the web site of IEA SHC Task 42:

http://task42.iea-shc.org/data/sites/1/publications/Task42-Annex-29-Position-Paper-and-All-Final-Deliverable-Papers.pdf

Outlook 2016: The ExCo's of IEA SHC and IEA ECES agreed on activities to start a new Joint Task on the topic of Compact Thermal Energy Storage. A Task definition workshop was carried out 6-8 April 2016, organized by Dr. Wim Van Helden and Dr. Andreas Hauer.

8. References

Results of IEA SHC Task 42 / IEA ECES Annex 29:

http://task42.iea-shc.org/data/sites/1/publications/Task42-Annex-29-Position-Paper-and-All-Final-Deliverable-Papers.pdf

Position Paper of IEA SHC Task 42:

https://www.iea-shc.org/data/sites/1/publications/IEA-SHC-Compact-Thermal-Storage-Position-Paper.pdf