Review of ideas to improve water tank storage

A Report of IEA Solar Heating and Cooling programme - Task 32
"Advanced storage concepts for solar and low energy buildings"

Report D1 of Subtask D

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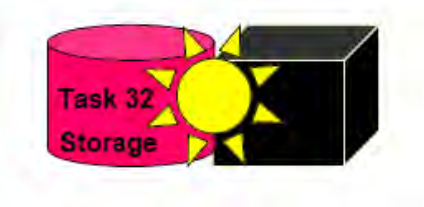

Review of ideas to improve water tank storage

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A report of Subtask D

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Executive Summary

This report presents ideas for improving water tank storage that Task 32 has adressed or proposed for future work.

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

IEA Solar Heating and Cooling Programme

The *International Energy Agency* (IEA) is an autonomous body within the framework of the Organization for Economic Co-operation and Development (OECD) based in Paris. Established in 1974 after the first "oil shock," the IEA is committed to carrying out a comprehensive program of energy cooperation among its members and the Commission of the European Communities.

The IEA provides a legal framework, through IEA Implementing Agreements such as the *Solar Heating and Cooling Agreement*, for international collaboration in energy technology research and development (R&D) and deployment. This IEA experience has proved that such collaboration contributes significantly to faster technological progress, while reducing costs; to eliminating technological risks and duplication of efforts; and to creating numerous other benefits, such as swifter expansion of the knowledge base and easier harmonization of standards.

The *Solar Heating and Cooling Programme* was one of the first IEA Implementing Agreements to be established. Since 1977, its members have been collaborating to advance active solar and passive solar and their application in buildings and other areas, such as agriculture and industry. Current members are:

Australia	Finland	Portugal
Austria	France	Spain
Belgium	Italy	Sweden
Canada	Mexico	Switzerland
Denmark	Netherlands	United States
European Commission	New Zealand	
Germany	Norway	

A total of 39 Tasks have been initiated, 30 of which have been completed. Each Task is managed by an Operating Agent from one of the participating countries. Overall control of the program rests with an Executive Committee comprised of one representative from each contracting party to the Implementing Agreement. In addition to the Task work, a number of special activities—Memorandum of Understanding with solar thermal trade organizations, statistics collection and analysis, conferences and workshops—have been undertaken.

The Tasks of the IEA Solar Heating and Cooling Programme, both underway and completed are as follows:

Current Tasks:

Task 32 *Advanced Storage Concepts for Solar and Low Energy Buildings*
Task 33 *Solar Heat for Industrial Processes*
Task 34 *Testing and Validation of Building Energy Simulation Tools*
Task 35 *PV/Thermal Solar Systems*
Task 36 *Solar Resource Knowledge Management*
Task 37 *Advanced Housing Renovation with Solar & Conservation*
Task 38 *Solar Assisted Cooling Systems*
Task 39 *Polymeric Materials for Solar Thermal Applications*

Completed Tasks:

Task 1 *Investigation of the Performance of Solar Heating and Cooling Systems*
Task 2 *Coordination of Solar Heating and Cooling R&D*
Task 3 *Performance Testing of Solar Collectors*
Task 4 *Development of an Insolation Handbook and Instrument Package*
Task 5 *Use of Existing Meteorological Information for Solar Energy Application*
Task 6 *Performance of Solar Systems Using Evacuated Collectors*
Task 7 *Central Solar Heating Plants with Seasonal Storage*
Task 8 *Passive and Hybrid Solar Low Energy Buildings*
Task 9 *Solar Radiation and Pyranometry Studies*
Task 10 *Solar Materials R&D*
Task 11 *Passive and Hybrid Solar Commercial Buildings*
Task 12 *Building Energy Analysis and Design Tools for Solar Applications*
Task 13 *Advance Solar Low Energy Buildings*
Task 14 *Advance Active Solar Energy Systems*
Task 16 *Photovoltaics in Buildings*
Task 17 *Measuring and Modeling Spectral Radiation*
Task 18 *Advanced Glazing and Associated Materials for Solar and Building Applications*
Task 19 *Solar Air Systems*
Task 20 *Solar Energy in Building Renovation*
Task 21 *Daylight in Buildings*
Task 23 *Optimization of Solar Energy Use in Large Buildings*
Task 22 *Building Energy Analysis Tools*
Task 24 *Solar Procurement*
Task 25 *Solar Assisted Air Conditioning of Buildings*
Task 26 *Solar Combisystems*
Task 28 *Solar Sustainable Housing*
Task 27 *Performance of Solar Facade Components*
Task 29 *Solar Crop Drying*
Task 31 *Daylighting Buildings in the 21st Century*

Completed Working Groups:
CSHPSS, ISOLDE, Materials in Solar Thermal Collectors, and the Evaluation of Task 13 Houses

To find Solar Heating and Cooling Programme publications and learn more about the Programme visit **www.iea-shc.org** or contact the SHC Executive Secretary, Pamela Murphy, e-mail: pmurphy@MorseAssociatesInc.com

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What is IEA SHC Task 32

"Advanced Storage Concepts for solar and low energy buildings" ?

The main goal of this Task is to investigate new or advanced solutions for storing heat in systems providing heating or cooling for low energy buildings.

- The first objective is to contribute to the development of advanced storage solutions in thermal solar systems for buildings that lead to high solar fraction up to 100% in a typical 45N latitude climate.

- The second objective is to propose advanced storage solutions for other heating or cooling technologies than solar, for example systems based on current compression and absorption heat pumps or new heat pumps based on the storage material itself.

Applications that are included in the scope of this task include:

- new buildings designed for low energy consumption
- buildings retrofitted for low energy consumption.

The ambition of the Task is not to develop new storage systems independent of a system application. The focus is on the integration of advanced storage concepts in a thermal system for low energy housing. This provides both a framework and a goal to develop new technologies.

The Subtasks are:
- Subtask A: Evaluation and Dissemination
- Subtask B: Chemical and Sorption
- Subtask C: Phase Change Materials
- Subtask D: Water tank solutions

Duration
July 2003 - December 2007.

www.iea-shc.org look for Task32

IEA SHC Task 32 Subtask D

"Water tank solutions"

This report is part of Subtask D of the Task 32 of the Solar Heating and Cooling Programme of the International Energy Agency dealing with evaluation of new storage concepts.

Task 32 participants gave a close look at what could be improved in a water tank storage as a key element of a solar combisystem.

The Operating Agent would like to thank all contributors of this report during the Task 32 period (2003-2007). We are convinced that ideas expressed in this report will find their way through research and testing and some will find their way to the market in order to improve storage efficiency or performances in the future.

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CONTENTS

1 INTRODUCTION

Storing solar energy in water in a tank is a well established technique.
Since 10 years much progress have been made on solar combisystem to achieve high storage performances and high system performances for instance thanks to stratifiers within the tank.

Task 32 worked on advanced concepts of storage. But water tank might still have a potential of improvements !

Task participants gathered in this report their ideas on possible improvements that could be investigated in the future for enhancing water tank storage for small systems (4 to 20 m² of solar collectors).

2 POSSIBLE IMPROVEMENTS or OPTIMISATION TRACKS

2.1 Global Design

- What is the best solution for the auxiliary boiler :To be placed internally (in the tank) or externally ? This is not yet known and the trend in the industry is to integrate the auxiliary in the tank to minimize space needed, to increase the boiler efficiency and reduce cost. But on the other hand the integration will result in a decreased efficiency of the solar part of the system. Detailed investigations are needed in this field.

- Is a more compact design better than a dispersed solution: control unit + pumps + valves all integrated into a well insulated box close to the tank or even in the tank mantle ?

- Can better stratification be achieved with new stratification enhancers (chimneys, light fabric, pipes, spirals, U shaped profile, etc..). There is a vast field of research possible on this topic, but the improvement compared to the current solutions might be small since we already achieve very high stratification in solar tanks.

- Should the domestic hot water preparation unit be Internal or external to the main storage tank ? And: if it is internal, should the DHW-volume be negligible or substantial. All three systems are on the market but no true comparison on similar basis have been published.

- What pressurized solutions in order to reach 120-150C in the tank can be designed ? What material ? What risks ? What cost ? There is here a potential of improving by 50% the storage density compared to the current limit of 95°C.

- Are Pressureless tanks to the opposite a better solution because less expensive, demanding less use of material and still efficient ?

- Are true drain back systems better than pressurized loop in terms of performances and cost of operation ?
- Are variable auxiliary volumes (“smart tanks”) like the ones proposed in DK a better solution ?
- What tank material(s) should be chosen ? plastic, steel, etc…, or combination ?
- A tank storage can store heat ? can it also store cold in summer ? How ?
- What storage tank shape is optimal ? A cylinder ?
- Cost reduction due to standardised storage and system concepts
- Polymer materials to reduce cost (collectors, pipes, storage, exchanger)

2.2 Testing

- Can we improve the storage testing methods to better caracterize its efficiency in stratification, using an exergetic approach ?

2.3 Modelling

- A complete auxiliary heater model (gas or oil) in conjunction with a tank storage model can be developed and will allow a more global optimisation of the tank + auxiliary part of the system.
- CFD simulation of water flows within the tanks and the connecting pipes are likely to help to improve tank designs and control strategies.
- Validation of detailed simulation models for standard solar combisytem heat storages
- Models of PCM units in water tanks

2.4 Reduce losses

- Insulation and pipe entries could be improved to reduce heat losses
- Vacuum insulation panels or rolls or others could be used
- Heat losses through bottom and feet of tanks can be reduced at low cost

2.5 Heat exchange

- Internal or external components (for instance: a heat exchanger for DHW) ?
- Forced or natural convection external to the tank ?

- Tank in tank or external DHW tank ? Which is best ? When ?
- Storage in glycol to avoid solar exchanger: is it a good solution ?

2.6 Energy Density

- What are the optimal storage volumes for different applications, if true full cost and savings are considered ?
- Where should phase change materials in combination with a tank storage be put ? To which extent ?
- With what material or substance could water be improved as a heat storage medium ?

2.7 Auxiliary

- What is the ideal interaction with a boiler ? How to control the relation boiler position-store volume to minimize losses and auxiliary and to minimize also the emissions of the boiler !
- Should the boiler be installed in parallel or in serie ?
- Should the solar tank be solar only and connected to the rest in serie ? There is a large potential of optimisation here, specially for retrofitting of old heating installations with some solar.
- Is a “natural convection” boiler a competitive solution ?

2.8 Water quality

- Which configuration yield to better DHW quality (tank in tank, heat exchanger, outside DHW tank, etc..) ?
- Is legionella a problem ? when ?
- Can we enhanced the physical properties of fluid (with magnets?) so that there is less clogging of exhangers for instance

2.9 Scaling reduction

- New solution to reduce scaling of heat exchanger in hard water environment involves tube in tube heat exchanger. Is it working ?

2.10 Connections to the tank

- Are “passive” mixing valves (without active controller) posible ? It is a good solution ?

- Can we simplify pipe connections to the tank ? to reduce heat losses, natural convection and to ease installation ?

- How to connect optimally all the pipes to and from the tank ? position, internal circulation effects, diffusion speed, currents, thermo-siphoning, …

2.11 Controls

- How to Optimally Control the auxiliary and the solar collector ?
-
- Prediction of consumption (DHW and space heating through genetic algorithms) and weather forecast (from meteorological institutes through internet) can be used to optimally control a solar heating system inclusive the auxiliary energy supply system. Is a predictive controller cost effective ?

- What will cordless control systems bring to storage efficiency ?

- Can an internet central controller do better than a decentralised one ?

2.12 Other medium

- Ionic fluids
- Other material than liquid water (Sorption) or in combination with water (PCM)
- Other materials and principle of storage (Chemicals)

3 Conclusions

Ideas for improving tank storage solutions have been given.

Some of them have been investigated in Task 32 and are reported in other Task reports.

Other deserves a close look and some research effort since water as a storage medium will certainly stay as a good choice for long.

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