
Chemical and sorption storage

Selection of concepts

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

Report B1 of Subtask B

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Report B1 of Subtask B: Selection of Concepts

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A technical report of Subtask B



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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

September 2007

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 B

“Chemical and sorption storage”

This report is part of Subtask B of the Task 32 of the Solar Heating and Cooling Programme of the International Energy Agency dealing with solutions of storage based on adsorption or absorption processes and on thermochemical reactions.

The density of storage for these techniques compared to that of water is theoretically 2 to 10 depending on the temperature range of comparison.

The report describes the five projects that have been selected for investigation within Subtask B.

Projects presented in this report reflect the knowledge of the participating body presenting the project.

The Operating Agent would like to thank the authors of this document for their implication in the search of future storage solutions for solar thermal energy, the key to a solar future for the heating and cooling of our buildings.

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for the Swiss Federal Office of Energy

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NOTICE:

The Solar Heating and Cooling Programme, also known as the Programme to Develop and Test Solar Heating and Cooling Systems, functions within a framework created by the International Energy Agency (IEA). Views, findings and publications of the Solar Heating and Cooling Programme do not necessarily represent the views or policies of the IEA Secretariat or of all its individual member countries.

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1 INTRODUCTION

Subtask B (Storage concepts based on chemical reactions and on the sorption principle) deals with stores that are furthest from market introduction at the time of IEA Task 32 (2003-2007).

Sorption stores are in a more advanced stage of development than chemical heat stores, and a couple of prototype stores have been built and tested that exploited the three types of sorption principles. Sorption can be split into three types: adsorption, absorption and solid/gas reaction.

Mugnier and Goetz [1] studied different pairs of sorbent/refrigerant for energy storage for cooling applications, both below and above 0°C. They concluded that best storage capacity for system above 0°C used water as the working fluid, with NaOH being best for absorption and CaCl₂, MgCl₂ and Na₂S for adsorption with salts.

Visscher et al. [2] studied thermo-chemical materials for use in chemical stores for seasonal storage of solar heat. They concluded that magnesium sulphate and iron hydroxide were best and that calcium sulphate and iron carbonate were also most interesting in this context.

A limited number of groups have been interested in participating in this subtask within Task 32. Of these, three are active working on adsorption, one on absorption and one on chemical reactions.

The concepts based on these technologies are presented by each team in this document. A common reporting format has been used. Basic information is provided with regards to the physical principle of the storage technique and the status of development.

More results on each technique can be found in the other reports of Subtask B.

2 Selected Projects

The selected projects, that have been active in the task, are summarised in the table 1 below, and are described in more detail in the next section.

Table 1: Selected projects within Subtask B of IEA-SHC Task 32.

| Group / Project | Description |
|---|--|
| ECN and Univ. Utrecht, Holland. <i>Compact chemical seasonal storage of solar heat.</i> | Theoretical analysis of suitable chemical reactions in the range 60 - 250°C. This part is completed. The following will be done if funding is found: experimental studies of material properties and then proof of concept practically for the chosen materials; system simulations with the Task 32 boundary conditions. |
| SERC, Högskolan Dalarna, Sweden. <i>Evaluation of thermo-chemical accumulator TCA.</i> | Measurements on a prototype TCA machine, based on a 3-phase closed absorption process, in the lab. Modelling of the process and of the prototype machine. System simulations for cooling in district heating and solar heating systems for Swedish conditions. System design and the simulation for the Task 32 boundary conditions. Monitoring of TCA machines installed for distributed cooling in district heating networks. |
| Institut für solartechnik SPF, Switzerland. <i>Sorption storage.</i> | Solid closed system adsorption process with zeolite or silica gel. Studies of material properties and theoretical analysis. Building and testing of a prototype store. Modelling of the store and system simulations with the Task 32 boundary conditions. |
| AEE-Intech, Austria. Sortech, Fraunhofer ISE, Germany. <i>Modestore (Modular high energy density heat storage).</i> | Design of closed system adsorption heat store with silica gel with all components integrated into one unit. Testing in the lab. Modelling of the store, design of system and then simulation for full scale domestic seasonal storage for the Task 32 boundary conditions. |
| TW, Univ. Stuttgart, Germany. <i>Monosorp.</i> | Initial study of open adsorption system using zeolite or silica gel. Heat storage and removal from the store utilises the ventilation heat recovery system of the house. Moisture in the house is used as the source for discharging the store, resulting in limited power availability. Modelling of the store and design of system. System simulations of seasonal storage for German conditions as well as the Task 32 boundary conditions. |

2.1 Principles

The three storage units using a closed process act as chemical heat pumps where energy is stored by breaking the bonding of the water with the relevant substance, evaporating it and condensing it for future use.

The heat of condensation is generally vented to ambient. For heat removal for delivery to the house, a free energy source at low temperature is required for evaporation of the stored water.

The steam binds once again with the substance, releasing heat at a higher temperature.

As these three systems all use water, the free energy source needs to be higher than approximately 5°C for evaporation to take place.

As these three systems all can act as reversible heat pumps, the initial market for them is likely to be for system providing **both heating and cooling with short term storage**, and not for long term storage.

2.2 References

- [1] Mugnier, D. and V. Goetz, *Energy storage comparison of sorption systems for cooling and refrigeration*. Solar Energy, 2001. **71**(1): p. 47-55
- [2] Visscher, K., et al. (2004) ECN Report ECN-C--04-074: *Compacte chemische seizoenopslag van zonnewarmte; Eindrapportage*, ECN, Petten, Holland.<http://www.ecn.nl/library/reports/2004/c04074.html>. ECN-C--04-074.

3 SELECTED PROJECTS IN SUBTASK B

3.1 *ITW, Stuttgart University (Henner Kerskes) FEBRUARY 2005*

A Project name: MonoSorp – a seasonal adsorption storage integrated to a building ventilation

Starting date: 2003

Institutions involved, industry partners country and persons:

1. Institut für Thermodynamik und Wärmetechnik, University of Stuttgart, Germany, Henner Kerskes

Financed through: not financed so far

B Type of storage

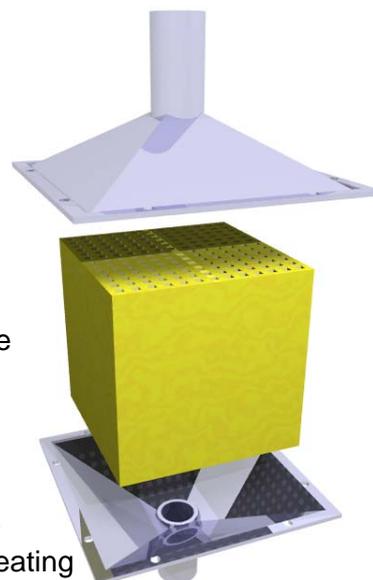
Adsorption storage in an open cycle adsorption process

Highly filled zeolite honeycomb structures made by extrusion of zeolite A4 powder using thermoplastic polymers as plasticizing aid and binder are used as adsorbent.

Honeycomb structures have decisive advantages compared with fixed beds of spheres or other shaped bodies. They show excellent adsorption kinetics and generate low pressure losses along the process length. In open cycle processes low pressure drop is important to minimize the electric power consumption of the fans.

In the system described below the indoor air is blown through the store, the humidity is adsorbed by the zeolite honeycomb and the resulting heat of adsorption can be used for space heating purpose.

The storage itself can be built by a number of smaller bricks. In this way even large storages can be built up inside small buildings with a wide range of geometries.



C System description, goal, capacity, performances, targets

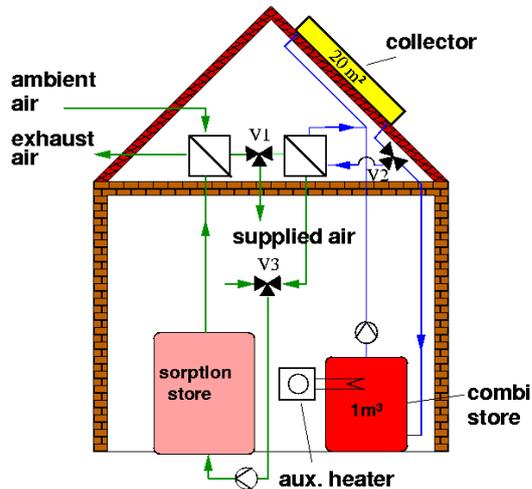
The adsorption store is working as a part of a mechanical building ventilation and in combination with a conventional solar combisystem.

In low energy buildings the amount of heat to cover the ventilation losses is up to 70 % of the total energy demand. Due to this fact modern buildings are often equipped with a heat recovery system. The described adsorption system is integrated to the building ventilation system.

During space heating season the indoor air is blown through the adsorption store. By adsorbing the air humidity the heat of adsorption is warming up the air stream. The resulting temperature lift depends on the relative air humidity and is in the range of 15 – 25 °C. The warm and dry air changes heat in the heat exchanger of the ventilation system. By this step

the ambient air is heated up to a temperature above the room temperature. The supplied air (ca. 40°C) becomes an active part for the space heating system of the building. In this phase the solar combisystem is operating in its normal manner and has no effect on the adsorption store.

After a certain time the store is saturated by water vapour.



The necessary heat for desorption is delivered by the solar system during summer. Then a conventional solar combisystem is needed just for domestic hot water preparation. With its large collector area (designed for space heating) a conventional solar combisystem has large stagnation time when it can not deliver any solar power. In the described system this time periods are used for the desorption of the adsorption store. This leads to high solar efficiency.

The desorption of the zeolite requires a bed temperature of about 160°C. For this purpose only highly efficient solar collectors (vacuum tube) are suitable.

The system itself is very simple with only a second heat exchanger and three valves are needed in addition to the adsorption store.

D Current progress

Preliminary tests on a honeycomb probe at laboratory size are carried out to investigate the performance of the adsorption and desorption processes. These tests were used to validate the numerical simulation of the ad- and desorption behaviour. A one dimensional model was developed and solved with the chemical engineering software code called PDEX.

In detailed simulation studies, where the building, the heating system and the solar combisystem were modelled in TRNSYS and the sorption processes with PDEX, the overall performance of the system was analysed. Yearly energy savings for a single family house were calculated under German reference conditions.

E Results:

Yearly energy savings were calculated for the following system:

Energy demand of the building: 7600 kWh (space heating and DHW preparation), 1 m³ combistore, 20 m² CPC vacuum tube collector area, 7.6 m³ sorption store.

The calculated energy saving is 70 %. This is the same amount a conventional solar combisystem can reach with a 20 m² water store and 50 m² collector area.

F Open questions

What kind of heat transfer fluid is suitable for the application?

What is the best adsorbent for this kind of application?

G Perspectives

A demonstration project is planned.

H References

H. Kerskes, W. Heidemann, H. Müller-Steinhagen, *MonoSorp- Ein weiterer Schritt auf dem Weg zur vollständig solarthermischen Gebäudebeheizung*, Tagungsband zum 14. Symposium Thermische Solarenergie, OTTI, Regensburg, 2003, ISBN 3-934681-33-6

3.2 SERC, Högskolan Dalarna (Chris Bales) DECEMBER 2004

A Project name: Evaluation of ThermoChemical Accumulator (TCA)

Starting date: December 2003

Due Date: December 2006

Institutions involved, industry partners country and persons:

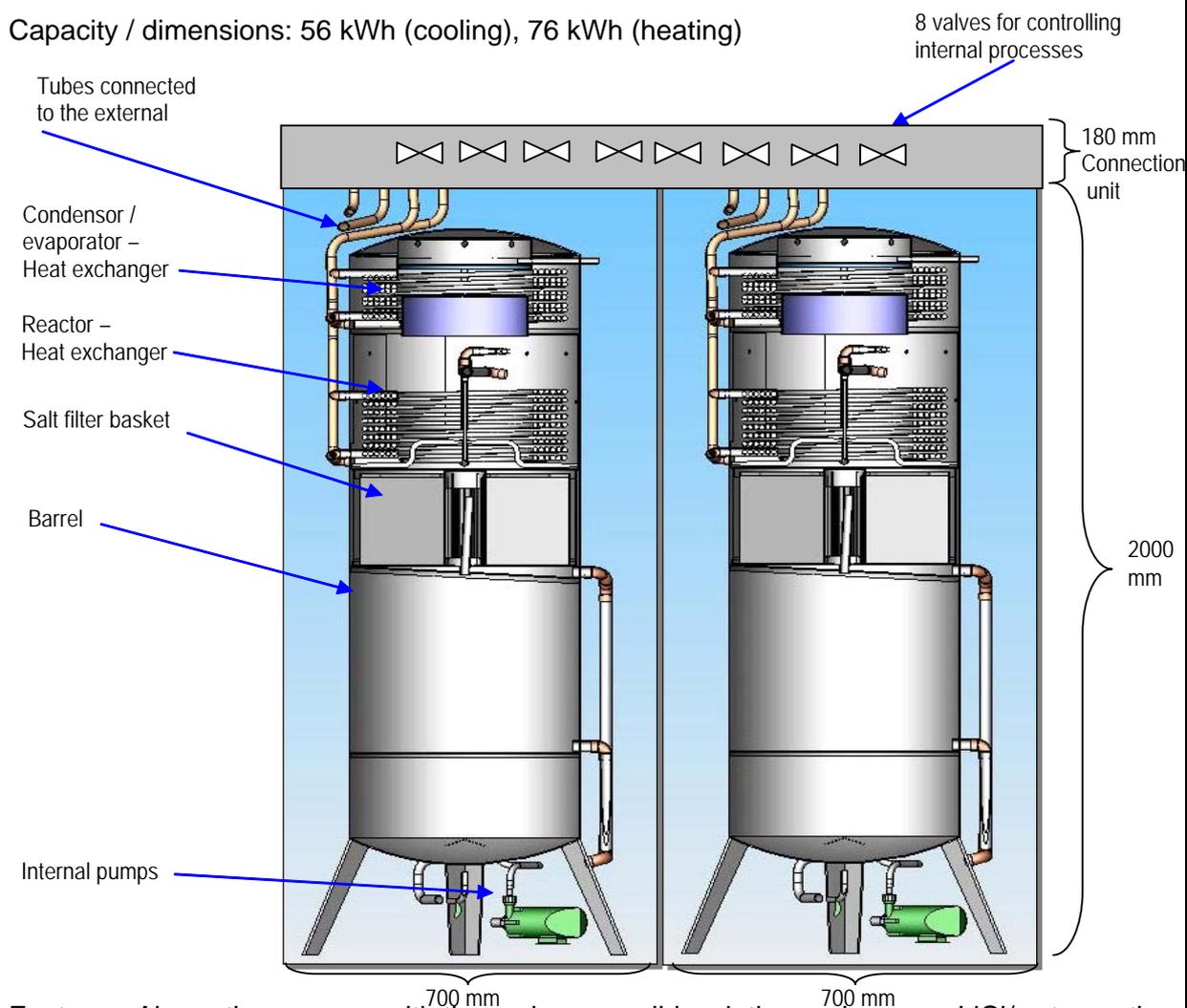
1. Solar Energy Research Center SERC, Sweden. Chris Bales, Svante Nordlander.
2. Fredrik Setterwall Konsult AB, Sweden. Fredrik Setterwall.
3. ClimateWell AB (industry partner, producer of TCA technology), Sweden. Göran Bolin.
4. Vattenfall AB (industry partner, potential user), Sweden. Stefan Larsson, Peter Krohn, Johan Lofdal.

Financed through:

Swedish National Energy Administration, own contributions from Fredrik Setterwall Konsult AB, ClimateWell AB, Vattenfall AB.

B Type of storage

Capacity / dimensions: 56 kWh (cooling), 76 kWh (heating)



Features: Absorption process with three phases: solid, solution and vapour. LiCl/water as the active substances with small amounts of inhibitors. During charging (regeneration), solution is pumped over the reactor heat exchanger and solid crystals are formed that fall under gravity and are collected in a basket. During discharge the solid crystals are dissolved using

the condensed water. Charge and discharge occur at constant operating conditions during three-phase operation. A single unit can either charge or discharge.

Availability on market:

Marketed as ClimateWell DB220 as an advanced industrial prototype. Sold to several groups.

Objectives:

1. Create a chemical heat pump with integral storage.
2. Develop the technology for small size cooling applications.
3. Investigate the performance in the field and in the lab.
4. Study potential application areas.
5. Modelling and system simulation.

What is new compared to state of the art knowledge ?

Three-phase absorption machine with integral chemical storage at high energy density.

C System description, goal, capacity, performances, targets

Technology developed as a component. System design and application has not been considered in detail yet, but prototype systems have been designed and installed for cooling using district heating or solar as heat source. A system will be designed and simulated for heating and cooling. Heat transfer to the ambient is required. Maximum designed heating and cooling capacities are 10 kW & 18 kW respectively and designed heat storage efficiency is 94%.

D Current progress

The TCA unit ClimateWell DB220 is version 7 and is in the industrial prototype stage, with a production line for manufacturing the units. Version 2 of the design was tested 2000-1 and is installed at 3 sites in Sweden, 2 driven by district heating and one by solar. Version 7 has been tested in ClimateWells lab and at at SERC's lab. Modelling in Trnsys is in progress. The TCA machines are being redeveloped based on the results of monitoring and testing.

E Results

Monitoring results show that the prototype machines performs worse than in theory. Main causes are non-condensable gases decreasing the vacuum, crystals not being kept in the designated area, poor valve performance and poor wetting of heat exchangers. New prototypes have been built that remove these problems and are being tested currently (Dec. 2004).

F Open questions, problems

Cooling and heating capacity and delivery temperatures are very dependent on the temperature of the free heat source and heat sinks. Careful system design is required as well as sizing of components in the system. System design has not been studied in detail before, but will be in the project. Uncontrolled crystallisation must be avoided.

G Perspectives

Commercial development will continue.

H References

- Bales, C., F. Setterwall and G. Boline (2004) Development of the Thermo Chemical Accumulator (TCA). In *Proceedings Eurosun 2004*, Freiburg, Germany.
- Setterwall, F. and C. Bales (2003) Thermo Chemical Accumulator - TCA. In *Proceedings ISES 2003*, Gothenburg, Sweden.
- ClimateWell (2004). Product Description ClimateWell DB220. ClimateWell, Sweden.
www.climatewell.com

3.3 *AEE-Intech (Dagmar Jaenig) JANUARY 2005*

A Project name: MODESTORE (Modular High Energy Density Sorption Heat Storage)

Starting date: April 1st, 2003

Due Date: March 31th, 2006

Institutions involved, industry partners country and persons

1. Fraunhofer ISE, Germany; Tomas Nunez
2. AEE INTEC, Austria; Waldemar Wagner & Dagmar Jaehnig
3. SOLPROS, Finland, Heidrun Faninger-Lund
4. ECOFYS, The Netherlands; Anton Shaap
5. PSE GmbH, Germany; Andreas Haerberle
6. SYH Swedish Polytechnic; Finland, Sten Engblom
7. SORTECH AG, Germany; Walter Mittelbach

Financed through: EU, FFF (Austria)

B Type of storage: Sorption Storage

Capacity / dimensions: small-scale prototype (350 l)

Features:

Availability on market: still under development, first pilot plant planned in 2005

Objectives:

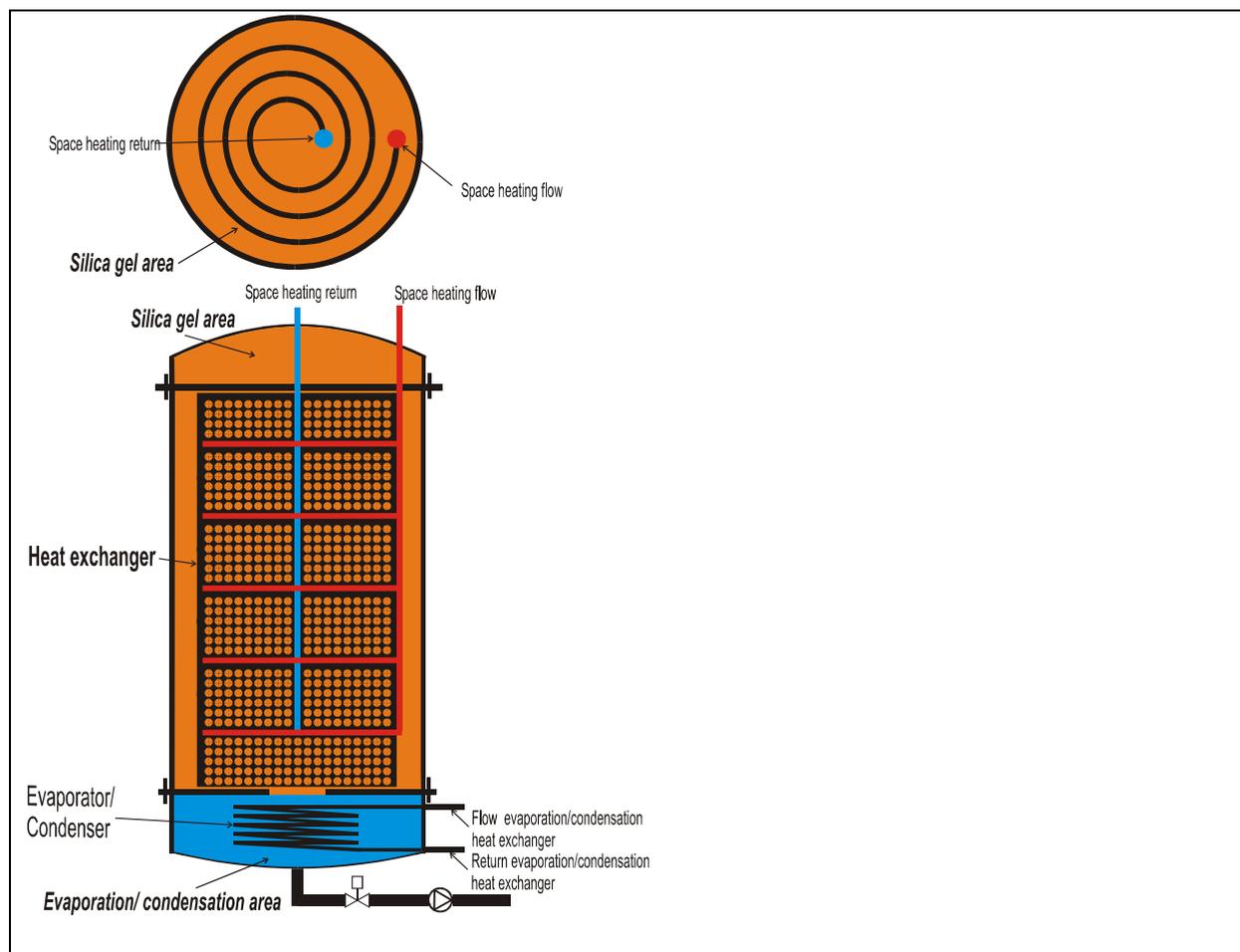
1. 100%-solar space heating system

What is new compared to state of the art knowledge? Up to now, the technical feasibility of the sorption principle has been proven. In this project, a functional pilot plant for a low-energy single-family house will be developed, installed and monitored.

C System description

High Energy Density Sorption Storage System on the basis of thermo-chemical processes (silica gel – water)

The key components (silica gel packing, heat exchanger, evaporator/condenser) are integrated into a single container. The laboratory-scale unit currently under investigation has a total volume of 350 l.



D Current progress

Development of a simulation model (TRNSYS)
 Development of 2nd generation system, experimental evaluation of a laboratory-scale prototype
 Installation of a first pilot plant planned in 2005

E Results

The desorption mode of the laboratory-scale prototype works well. For the adsorption mode, a suitable control strategy is still under development.

F Open questions, problems

Control strategy and system design has to be finalized for the pilot system. Because the system operates as a chemical heat pump, the availability of a low temperature heat source in winter is a key issue for a successful operation of the system. Vacuum technology is expensive and not common. The goal is a compact systems with as few vacuum connections as possible.

G Perspectives

Monitoring of the system under real operating conditions; system will be installed in a single-family house with a solar heating system and low temperature heating distribution system; the energetic characteristics of the system and the relevant temperatures will be measured for at least one year.

H. References

J. Welteroth, W. Mittelbach: Final Report HYDES Project for the European Commission (2001)

Tomas Nunez, Hans-Martin Henning, Walter Mittelbach: High Energy Density Heat Storage System – Achievements and Future Work, ISES Solar World Congress 2003, Göteborg, Sweden

Günter Gartler, Dagmar Jähnig, Gottfried Purkarthofer, Waldemar Wagner: Development of a High Energy Density Sorption Storage System; EuroSun 2004; Freiburg, Germany

3.4 *ECN (Klaas Visscher) JANUARY 2005*

A Project name: Compact Chemical Seasonal Storage of Solar Heat

Starting date: September 1st, 2002 Due Date: December 31st, 2003
 Institutions involved, industry partners country and persons
 1. ECN (Energy Research Center of the Netherlands)
 2. University of Utrecht, Chemical Thermodynamics group
 Financed through: Novem (Dutch Government)

B Type of storage: Thermo-chemical

Capacity / dimensions: 8000 kWh to 11000 kWh: size to be minimised
 Features: General reaction type $A + B \rightleftharpoons C + \text{heat}$
 Availability on market: feasibility study
 Objectives:
 1. To find suitable materials for seasonal storage at temperatures between 60 and 250°C
 2. To estimate maximum possible performance taking into account only unavoidable energy losses.

What is new compared to state of the art knowledge?
 Solar collectors have reached a point where 40% efficiency can be achieved at 220°C in northern climates.
 TCM's in the temperature range 60 – 250°C seem not to be studied very well.

C System description

1) Material selection through literature search and material experiments. Detailed working process is not part of the investigation.
 2) Feasibility study through simulation of the seasonal storage for a single-family house where only energy losses are accounted for that cannot be avoided.

D Current progress

1) Laboratory tests
 2) Simulation results
 3) Study finished but financing is applied for in order to carry on the next stage which is proof of concept with more experimental work.

E Results

1) List of candidate materials
 2) Simulation model of TCM storage for a single-family house

F Open questions, problems

1) Kinetics of reactions
 2) Process design

G Perspectives

Choose materials from the list of candidate materials and design of a system.

H. References

Visscher, K., et al. (2004) ECN Report ECN-C--04-074: *Compacte chemische seizoenopslag van zonnewarmte; Eindrapportage*, ECN, Petten, Holland.
<http://www.ecn.nl/library/reports/2004/c04074.html>. ECN-C--04-074.

3.5 *SPF (Paul Gantenbein) JANUARY 2005*

A Project name: Sorption Storage

Starting date: July '03 Due Date: Dec. '06

1. Institution involved: Institut für Solartechnik SPF.

2. Industry partners: Not defined.

3. Country: Switzerland.

Financed through: BFE - Swiss Federal Office of Energy.

Specific Web site: www.solarenergy.ch - www.energie-schweiz.ch.

B Type of storage: Solid sorption

Capacity / dimensions: Theoretical 5 kWh.

Features: Solar operated solid material sorption storage heat pump of as low as possible movable parts.

Availability on market: No, cooling machine yes.

Objectives: *Prototype storage tank*

1. Increasing the solar energy fraction of buildings.

2. Solid sorption storage heat pump system.

3. Prototype storage tank with the aim of building/room climate conditioning.

C System description

Closed system operating with solid sorption materials (Silicagel, Zeolite, ...) and Water with the sun as the basic thermal energy source to increase the solar fraction in the energy demand of buildings. The system will operate as a thermally driven heat pump. As less as possible movable parts will be achieved. Theoretical power of 5 kWh.

D Current progress

Design level: System and components in the design level.

Laboratory tests: Experiments with available materials to support design of components.

Simulation results: Not yet. Will be necessary for the layout of integrated system.

Pilot plants: Not yet. Project with the objective of a pilot sorption storage tank.

E Results

Temperature lift and energy density of adsorbents in function of adsorbat temperature. Qualitatively measured mass transfer zones in the adsorbent to get knowledge of the basic processes. Water uptake and temperature profiles in function of time and location in the adsorbent in the discharging and charging mode to find out the geometrical dimensions of the heat exchanger immersed in the sorbent bed.

F Open questions, problems

In keeping the eyes on the choosed system type we face low heat transfer rates from the heat exchanger to the adsorbent and vice versa. So the optimal design has to be determined, which means that the geometrical parameters have to be determined. The power limits by the pressure drop in a adsorbent fixed bed in relation to the investment is still an unanswered question. In Case of zeolite high charging temperatures are necessary leading to lower efficiency in the real application.

G Perspectives

Difficult market competition because of low cost of fossil fuel.

H References

Annual reporting to the BFE - Swiss Federal Office of Energy is required.

4 Conclusions

Five projects have been presented by participants in Subtask B (Chemical and sorption storage) of IEA SHC Task 32 (Advanced storage concepts).

The status of these projects are different, from a basic idea to an almost commercial product. Some are more suited for seasonal storage, and some have to be seen more as chemical heat pumps for both heating and cooling.

The development of these new storage technologies is essential to support the development of solar heating in countries with climate where seasons are noticeable.

Storage of heat can also be of importance for solar cooling in situations where cooling loads are observed over 24 hours.

Subtask B will report more results on the five projects described in this document in future reports issued by Task 32.