ECN

Energy research Centre of the Netherlands

ZAE BAYERN

4224

A new IEA joint SHC/ECES Task

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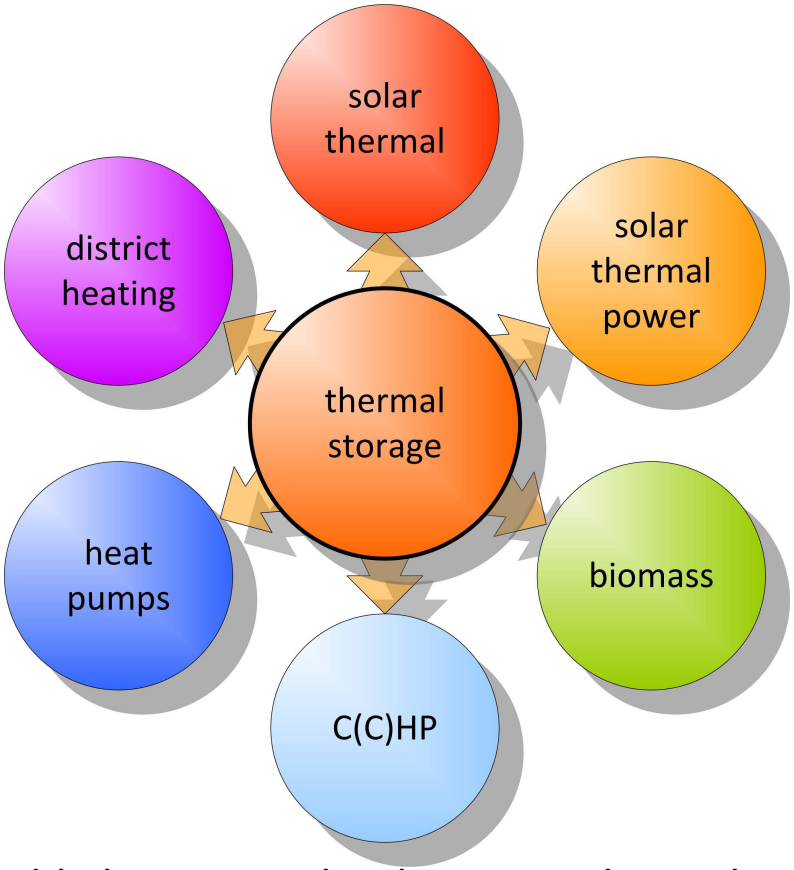
ECN SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY 4224 ECES ZAE BAYERN

Compact Thermal Energy Storage: Material Development for System Integration

Develop advanced materials for compact thermal storage systems

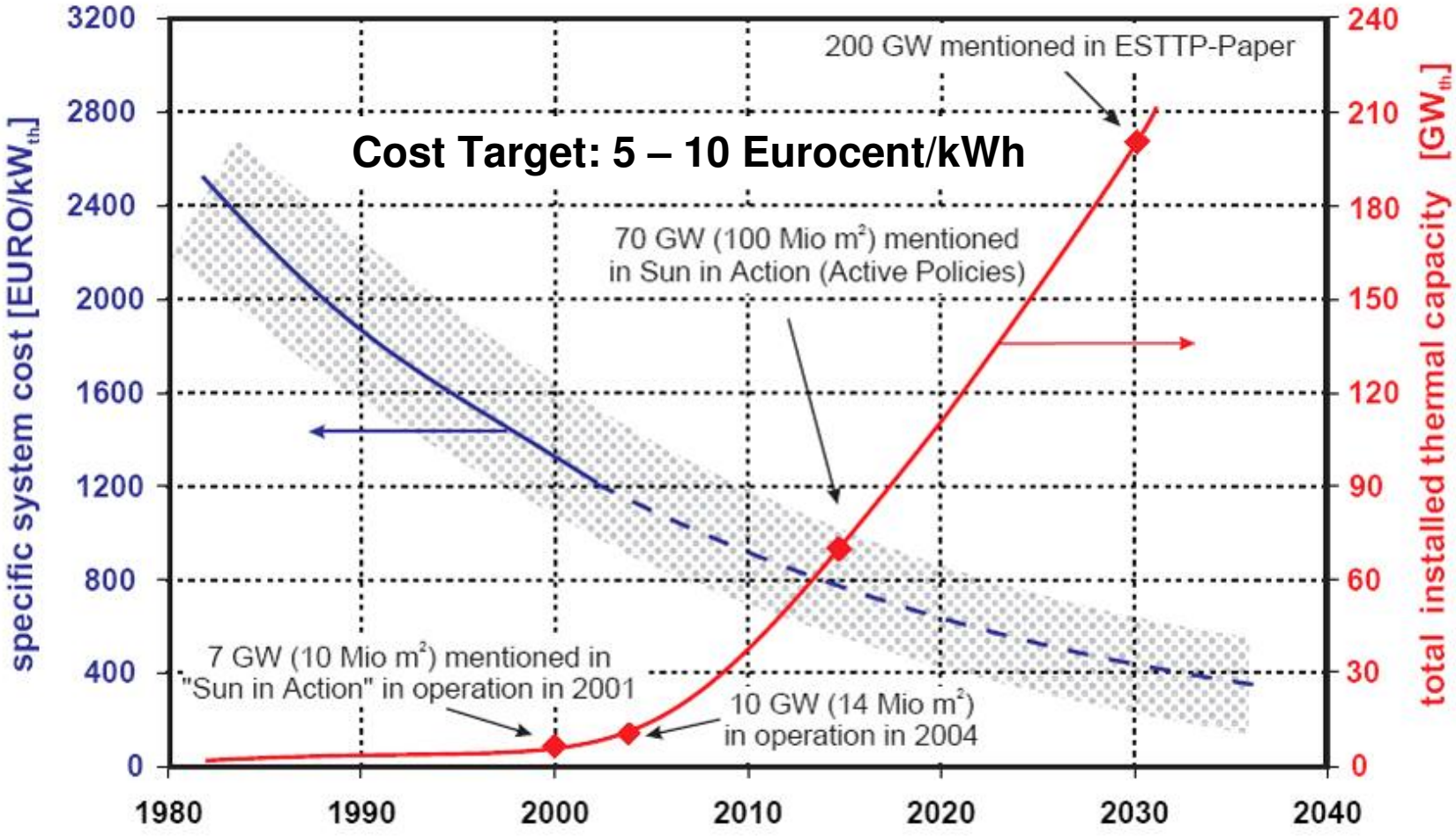
Bring together experts from material science and system applications

Why thermal energy storage?



Every renewable heating technology uses thermal energy storage!

Target: Cost Reduction by Economies of Scale and Technological Development



content

- Numerous application areas
- A material can serve different applications
- Matrix approach
- Questions before answers (42!)
- How can we advance in performance, R&D
- Co-development: system requirements and material possibilities
- Development line: magnesiumsulphate
- Dev line: zeolite bricks
- Dev line: superinsulating materials

Objectives

To develop advanced materials and systems for the compact storage of thermal energy:

- Identify, design and develop new materials and composites
- Develop measuring and testing procedures to characterise these new materials reliably and reproducibly
- Improve performance, stability and cost-effectiveness of new storage materials
- Develop multi-scale numerical models
- Develop and demonstrate novel compact TES systems employing the advanced materials
- Assess the impact of new materials on the system performance in different applications
- Disseminate the knowledge and experience acquired in this task

To create an active and effective research network

Timeline

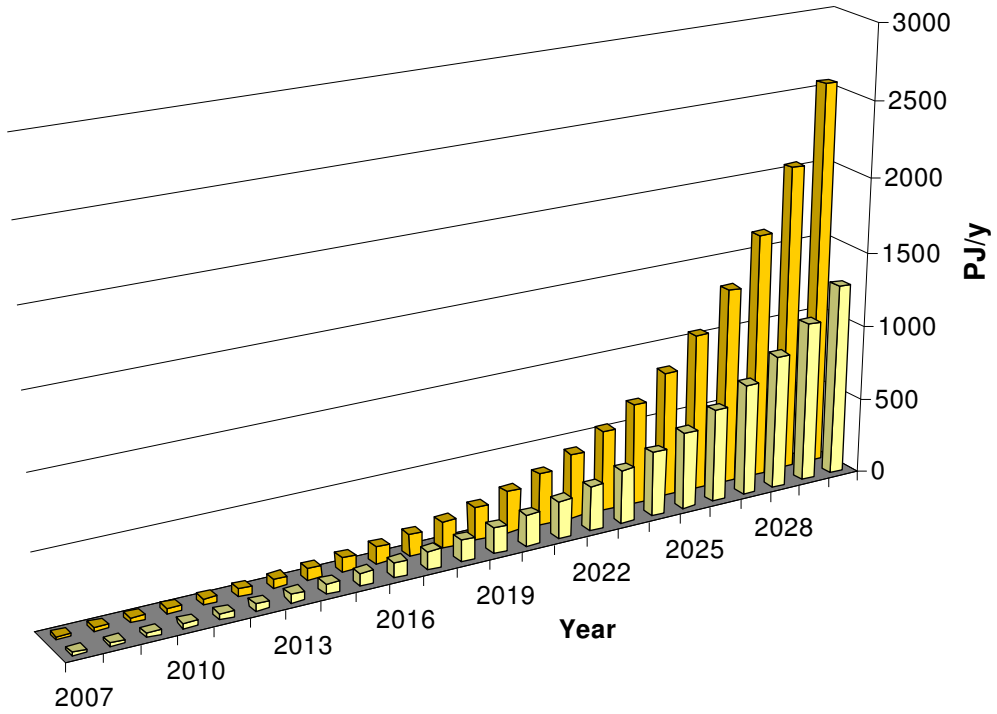
October 2007	First task discussion meeting, Zürich
Nov/Dec 2007	Presentation at ECES and SHC ExCos
Jan-Jun 2008	Draft Task Work Plan and Task Annex including Workshop, task definition meeting
April 10,11	Task Definition Meeting in Petten, NL
June 2008	Discussion of Draft in ExCo meetings of ECES (Bordeaux) and SHC (Graz)
Second half 2008	Finalising documents Securing funds Presentations at Thermische Solarenergie (Staffelstein), Eurosun (Lisbon), IMECE (Boston)
2009-2012	Four-year task/annex

Interested organisations

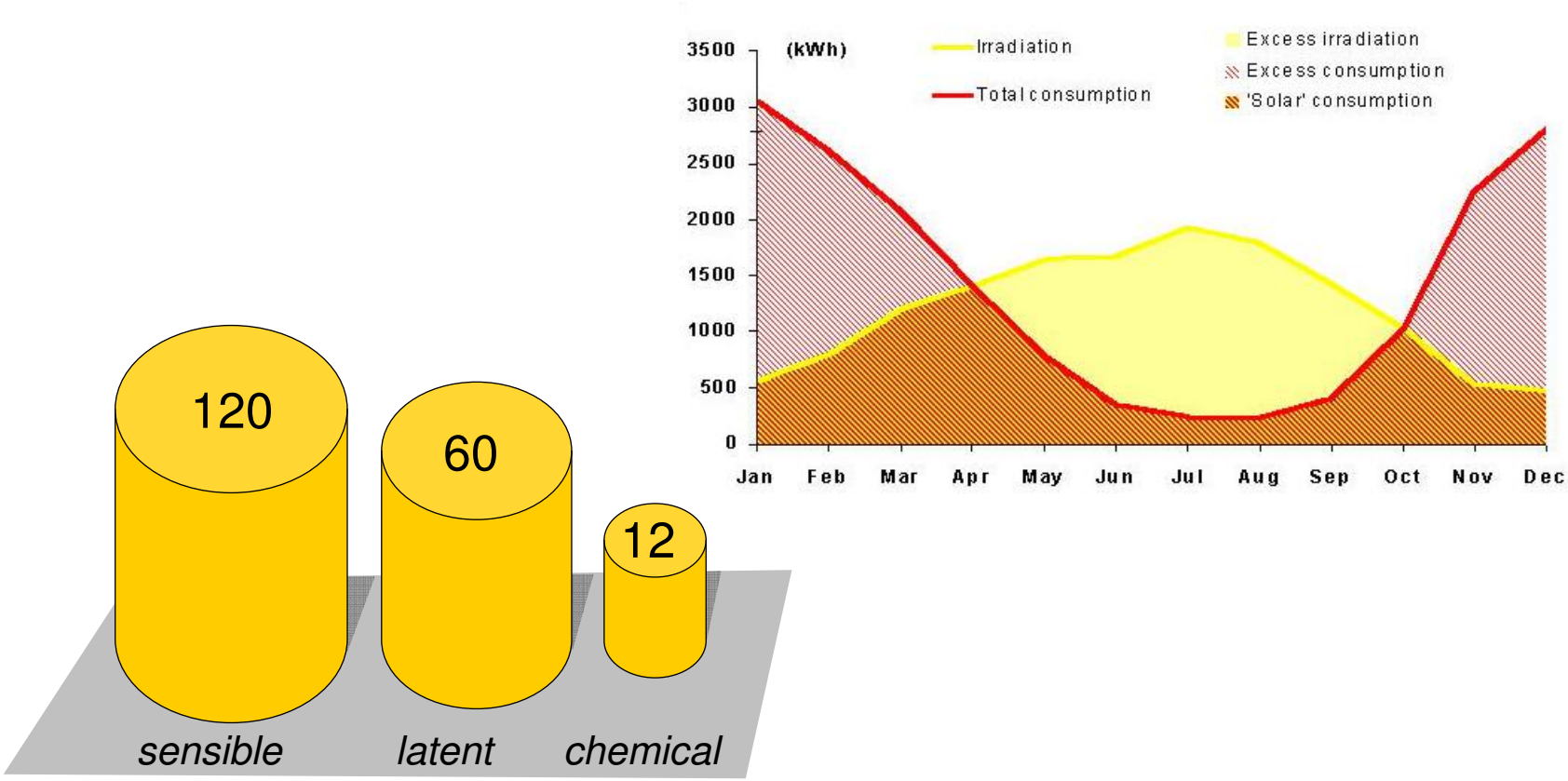
AT	AEE Intec	Dagmar Jaehnig
AT	University of Graz	Wolfgang Streicher
CA	Hydro Quebec	Karine Lavigne
CH	Base Consultants	Jean-Christophe Hadorn
CH	EMPA	Viktor Dorer
CH	HEIG-VD	Jacques Bony
CH	SPF	Paul Gantenbein
DE	Energie- und Projektberating	Jan Mugele
DE	Fraunhofer ISE	Peter Schossig
DE	Fraunhofer UMSICHT	Clemens Pollerberg
DE	ISFH	Dietmar Gross
DE	ITW Stuttgart	Harald Drück
DE	University of Kassel	Klaus Vajen
DE	Vaillant	Max Bankowski
DE	ZAE Erlangen	Franziska Scheffler
DE	ZAE Garching	Andreas Hauer
DE	Zeosys	H. Stach
DK	DTU	Jørgen Schultz
ES	Abengoa Solar NT	Gustavo Caceres
ES	Acciona	Javier Gravalos
ES	Inasmet Tecnalia	Patricio Aguirre
ES	Tekniker	Garikoitz Beobide
ES	University of Lleida	Lluisa Cabeza
ES	Universidad de Zaragoza	Pablo Dolado
FI	VTT	Lisa Wikstrom
FR	CSTB	Peter Riederer
FR	EDF	Philippe Stevens
FR	GRETH	Bernard Thonon
FR	INES	Philippe Papillon
FR	University of Perpignan	Vincent Goetz
FR	University of the Savoie	Lingai Luo
IL	Ben-Gurion University	Gennady Ziskind
NL	ECN	Marco Bakker, Wim van Helden
NL	Entry Technology	Jacob van Berkel
NL	TNO	Lucienne Krosse
NL	University of Eindhoven	Camilo Rindt
SE	Chalmers University	Jan-Olof Dalenback
SE	Dalarna University	Chris Bales
SE	FSK	Fredrik Setterwal
SI	KI	Venceslav Kaukic
SI	Silkem	Andrej Horvat
UK	Ciba Specialty Chemicals	Kishor Mistry
UK	University of Warwick	Philip Eames

Long-term effect of compact heat storage

- Gradual introduction of improved compact storage technologies starting in 2015
- Generated solar thermal energy in EU doubles in 2030



Seasonal storage of solar heat



Storage volume (m^3) needed for a very energy efficient household

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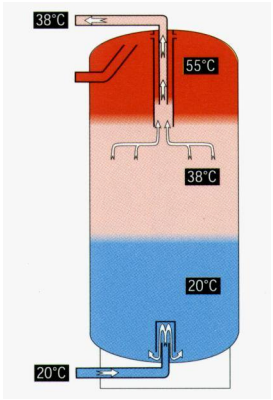
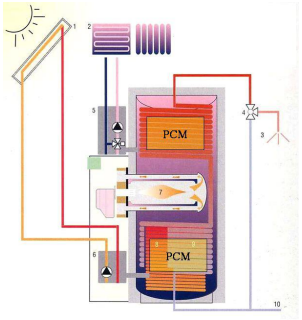
Why compact thermal storage

Stage of development of Thermal Energy Storage technologies

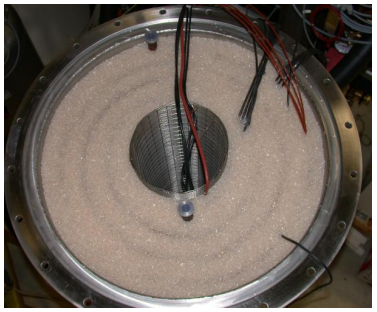
Water (sensible)
Mature market

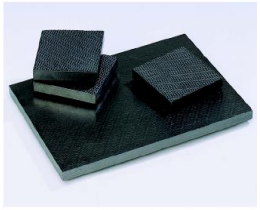


PCM (latent)
Demonstration

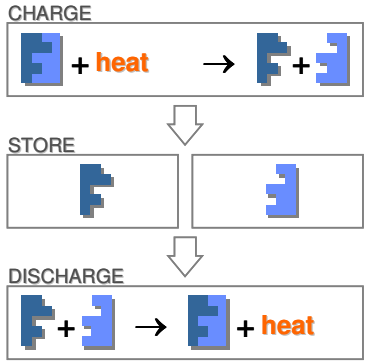


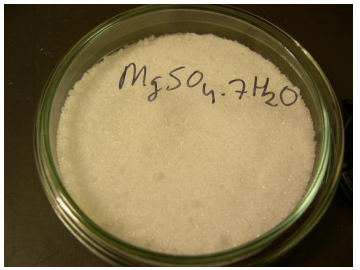
Sorption (physical)
Development





TCM (chemical)
Research

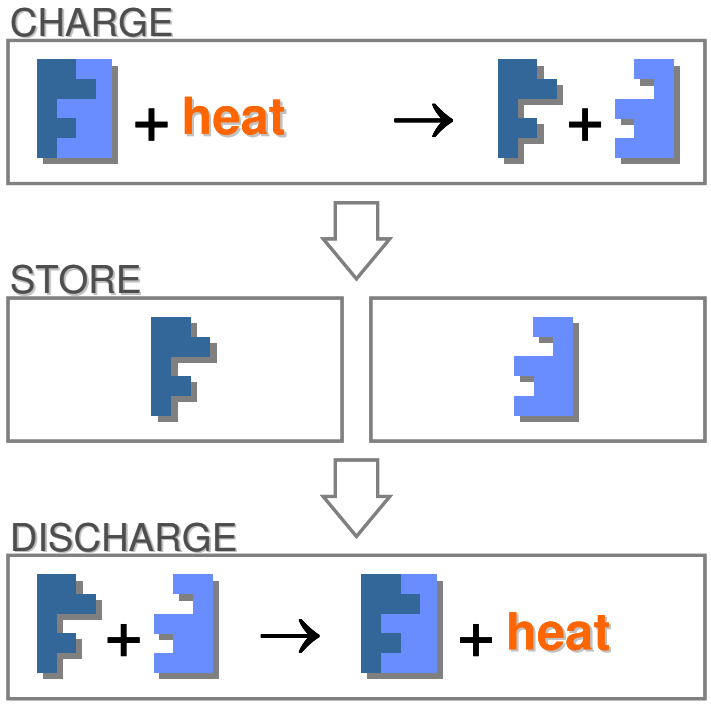




Chemical heat storage

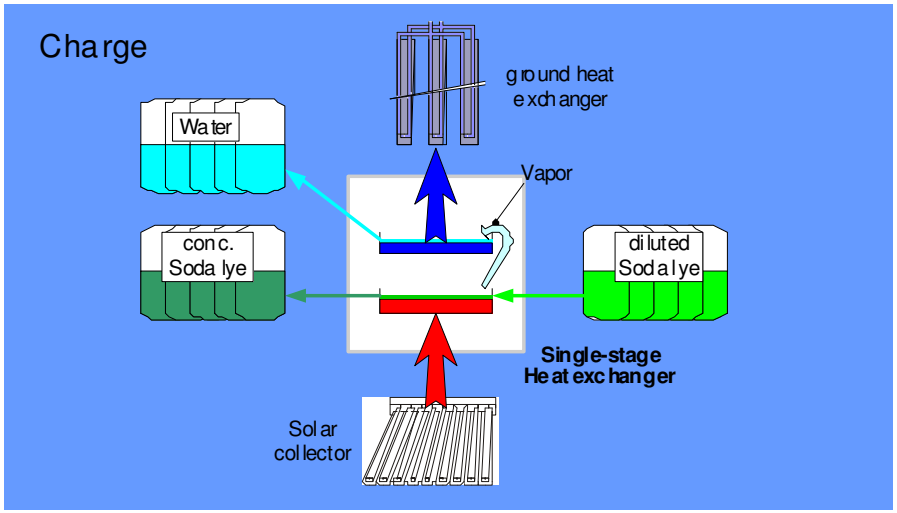
General principle **A + B ó AB + heat**

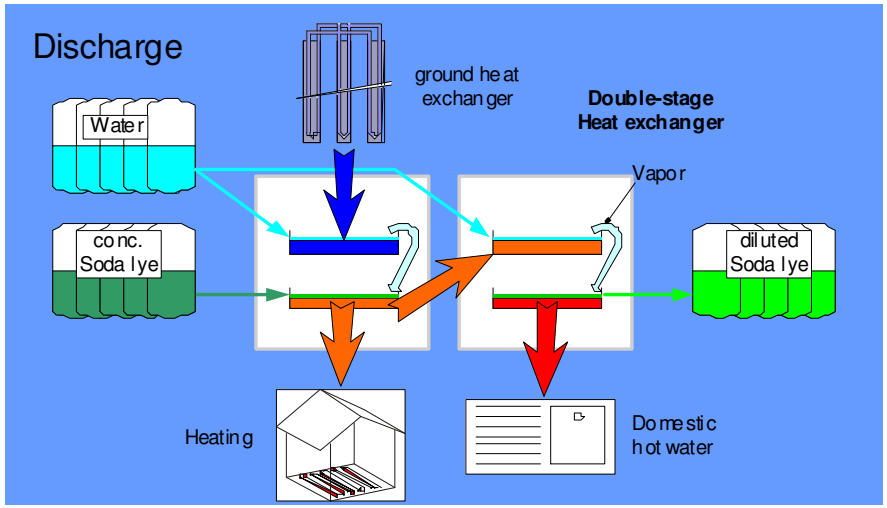
- Components stored sepearately without heat loss
- Long term heat storage
- Charge with temperatures typically higher than 100ºC
- Storage capacity between 250 and 4000 kJ/kg



Sodiumhydroxide Storage (EMPA – CH)

$$2NaOH \Leftrightarrow Na_2O + H_2O$$





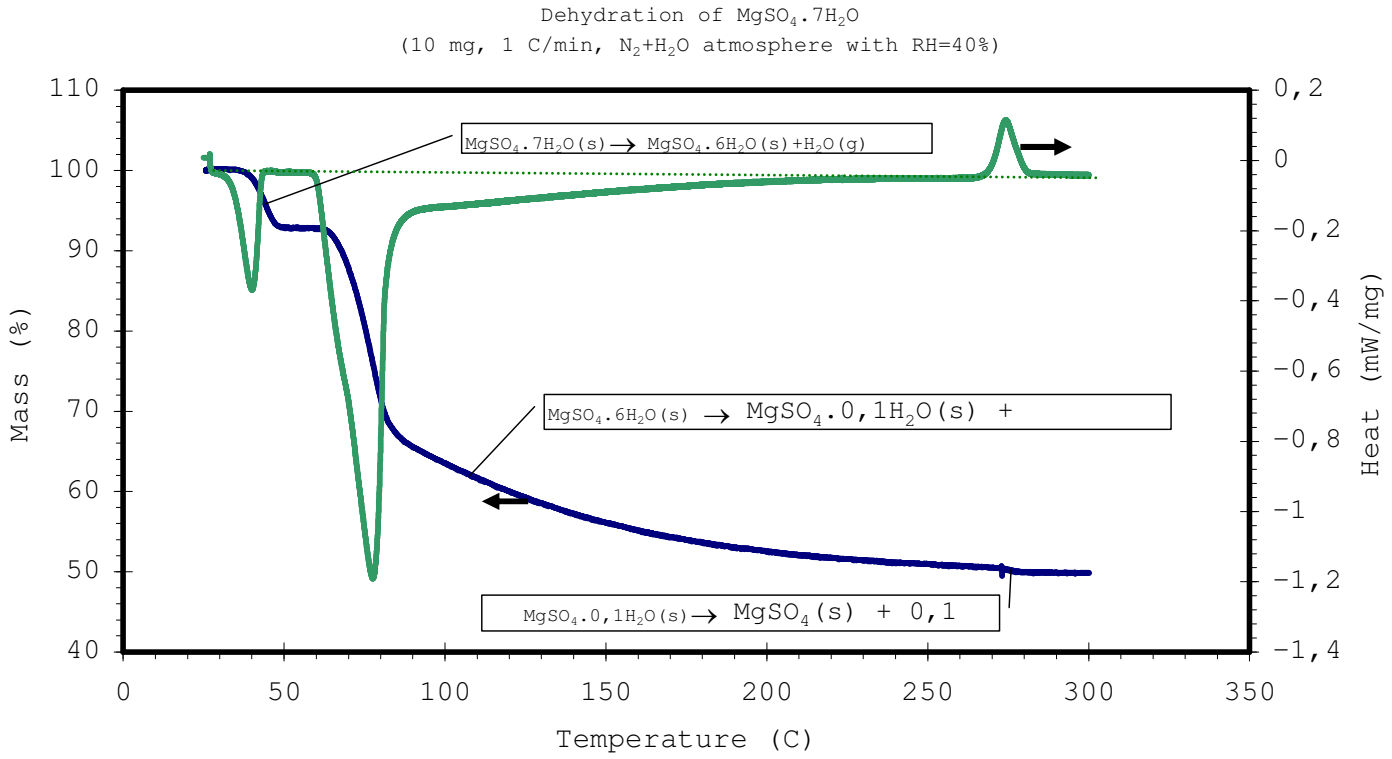
Materials selection (ECN, 2004)

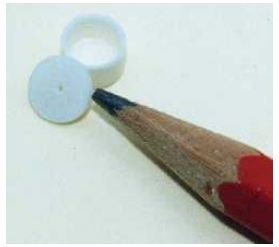
Material name	Dissociation reaction			Energy storage density of C	Turnover Temperature
	C ⇔	B +	A	GJ/m3	°C
Magnesium sulphate	MgSO4.7H2O	MgSO4	H2O	2.8	122
Iron carbonate	FeCO3	FeO	CO2	2.6	180
Iron hydroxide	Fe(OH)3	FeO	H2O	2.2	150
Calcium sulphate	CaSO4.2H2O	CaSO4	H2O	1.4	89

Principal criteria: energy storage density, temperature

Thermochemical material – $MgSO_4x7H_2O$

Reaction: $MgSO_4xnH_2O$ + heat → $MgSO_4$ + nH_2O

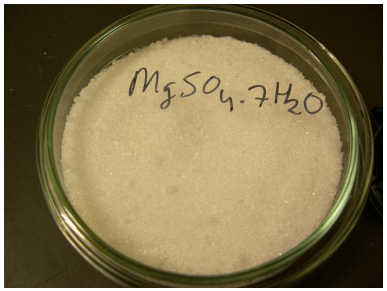


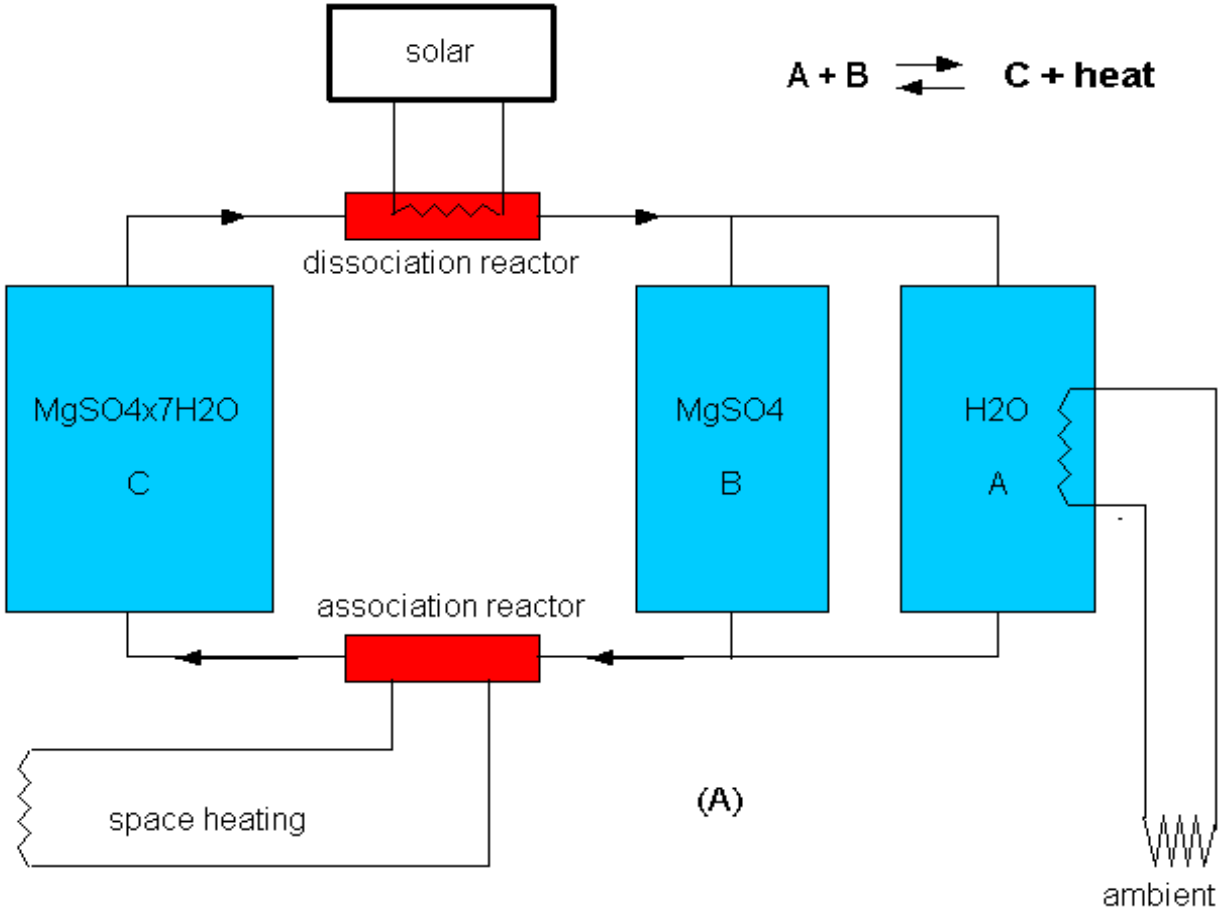


Sample mass decreases at increasing temperature

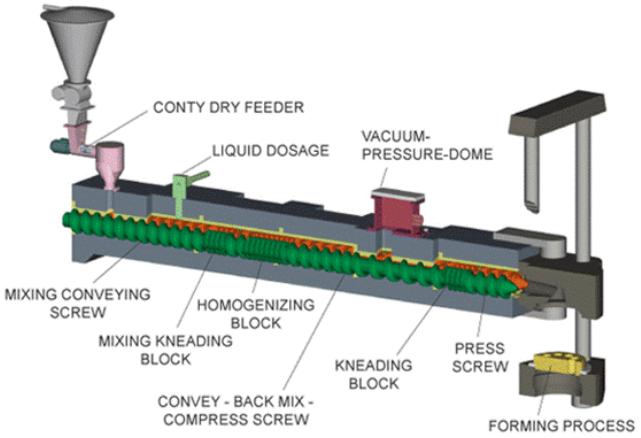
Magnesiumsulphate (ECN –NL)

Separate reactor concept

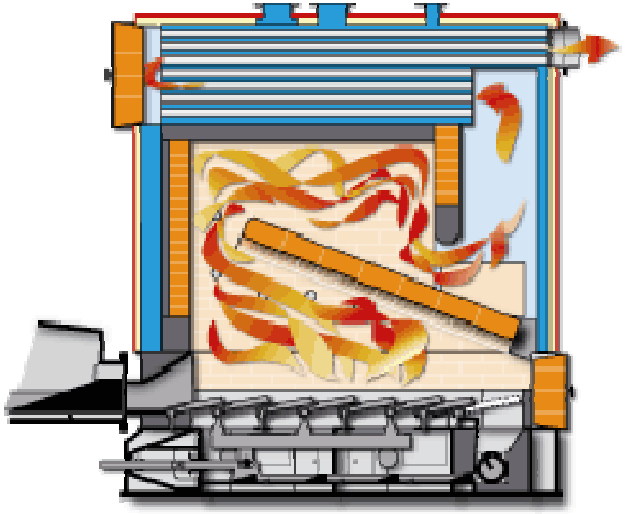




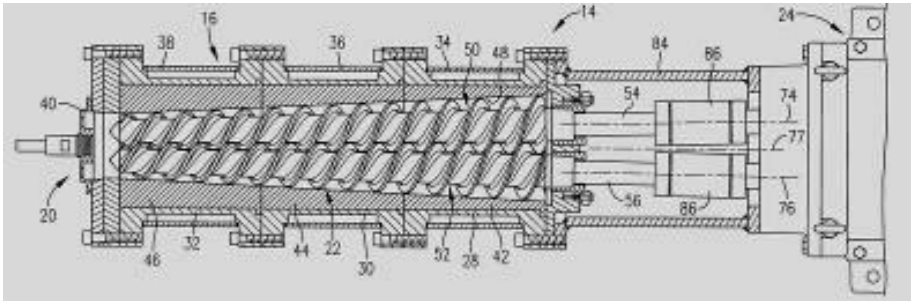
Reactor concepts



Hot screw dryer,extruder



Moving grate dryer



Compact thermal stores: a long way to go

- Morphology: influence of cracks
- Influence of impurities
- Long-term cycling behaviour
- Models to understand the kinetics and heat and mass transport
- Reactor design, taking material properties into account
- Numerical modelling and optimisation of reactors
- Material production process
- …and so on and so forth

Compact Thermal Energy Storage Development: International approach

- The vast task cannot be achieved by one single institute or one single country

- International collaboration
  - Of experts from different fields
  - In a programmed research effort

International Initiatives for Compact Thermal Energy Storage

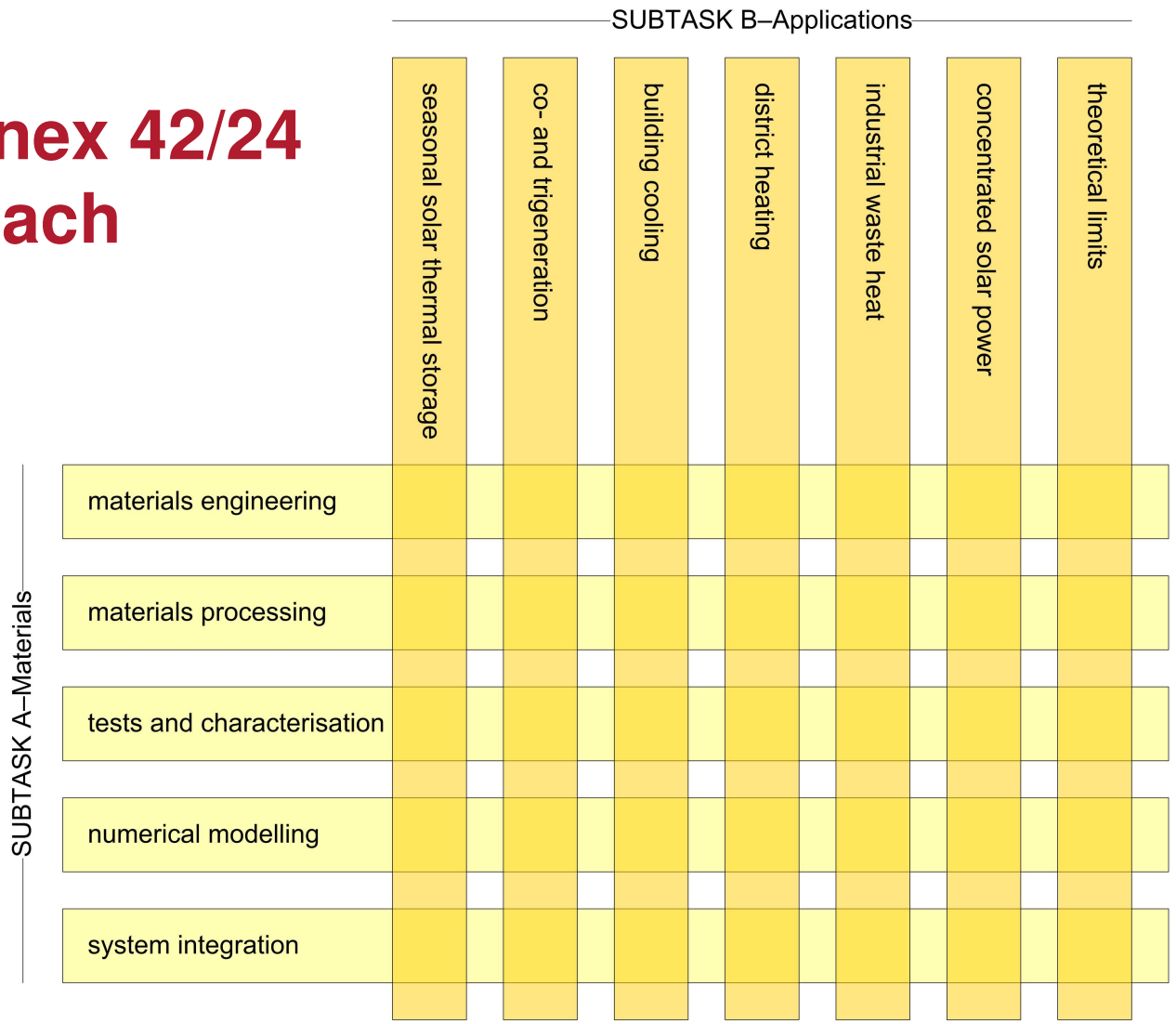
European Solar Thermal Technology Platform

Strategic Research Agenda

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Joint IEA Task/Annex 42/24:
Compact Thermal Energy Storage
Material Development for System Integration

IEA Task/Annex 42/24
Matrix approach



The building blocks for Compact Thermal Energy Storage

- Political awareness
- International programmed approach
- Active national participation
- Active industrial participation
- Clever ideas from..
- ..Bright enthusiastic people
- A load of money