UNIEKE WARMTEBATTERIJ SLAAT ZONNEWARMTE OP

TNO innovation for life

NVDO-Maintenance for Energy – 22 juni 2017

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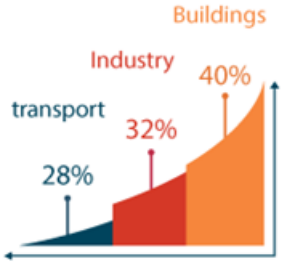
OVERVIEW

TNO innovation for life

TNO

- Independent Research & Innovation institute for Government and Industry
- Established by law in 1932
- Not-for-Profit
- 5 focus areas: Industry
  (in transition) Healthy Living
  Defence, Safety & Security
  Urbanisation
  Energy
- Approx. 3500 people
- Deeply involved in national and international research programmes

ENERGY BUILT ENVIRONMENT



ENERGY CONSUMPTION

Buildings account for 40% of the European Union's total energy consumption.

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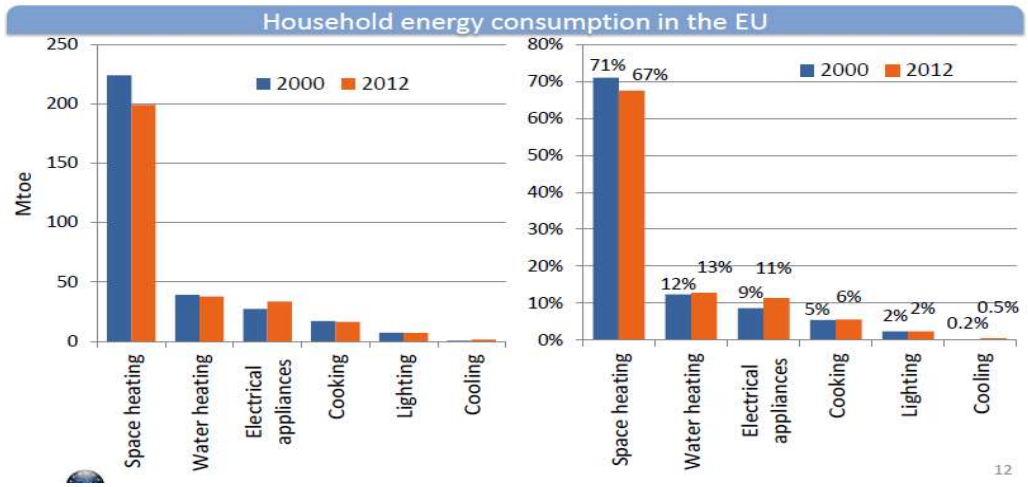
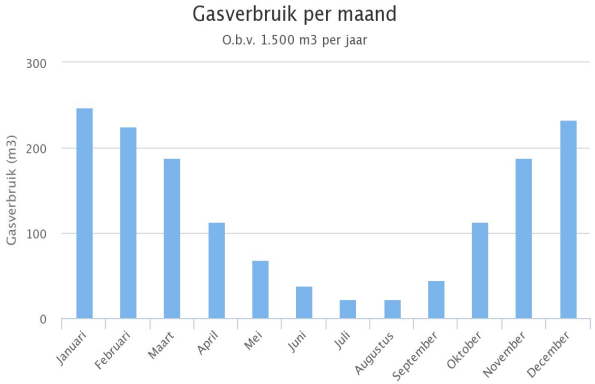


~ 80 % heat

NL average (gas):
~ 1500 m3 gas
~ 50 GJ
~1000 Euro/yr

NL: 97 % houses gas connected

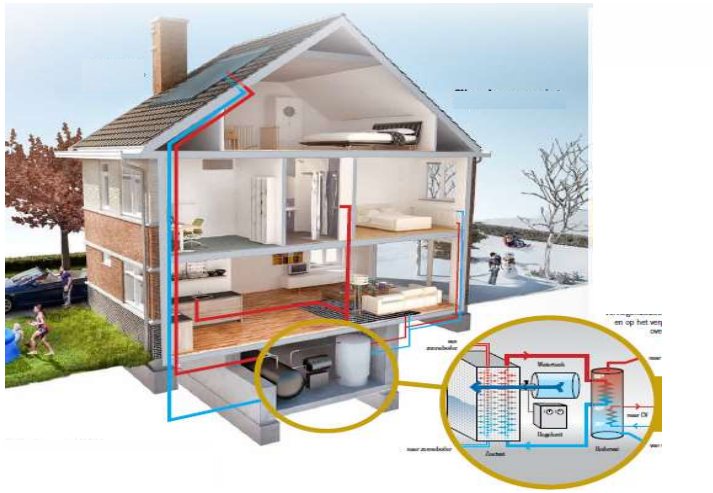


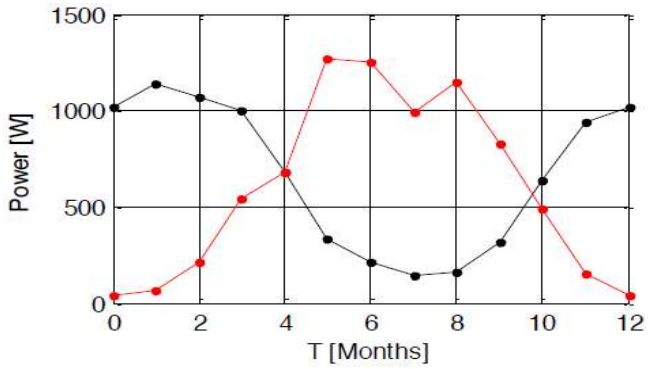
ENERGY PRODUCING BUILDINGS

- Maximise energy production
- Optimise energy storage (short/long term)
- Minimise use (while maintaining comfort & health)

TCM SEASONAL STORAGE OF SOLAR ENERGY

- Total roof collector heat suffices for space heating of dwellings (alternatively: PV + Heat pump system)
- Excess heat in summer stored for later use in winter
- E.g. 10GJ storage → ~10m^3 system → ~1GJ/m^3 guideline

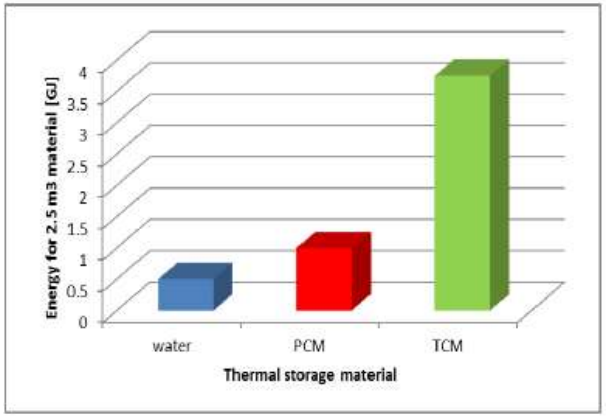




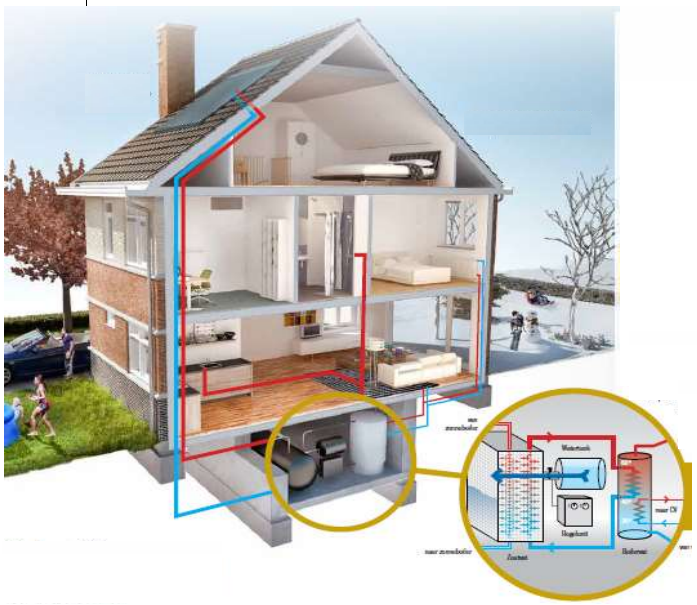
HEAT STORAGE

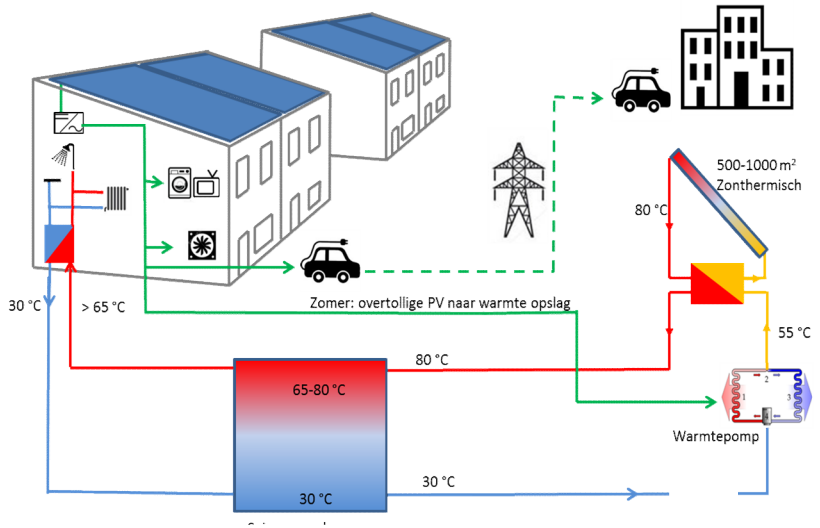
Possibilities for thermal energy storage:

1. Sensible (water)
2. Latent (PCM)
3. Thermochemical:
   1st generation: *Ad*sorption (silica gel, zeolites)
   2nd generation: *Ab*sorption (salt hydrates)

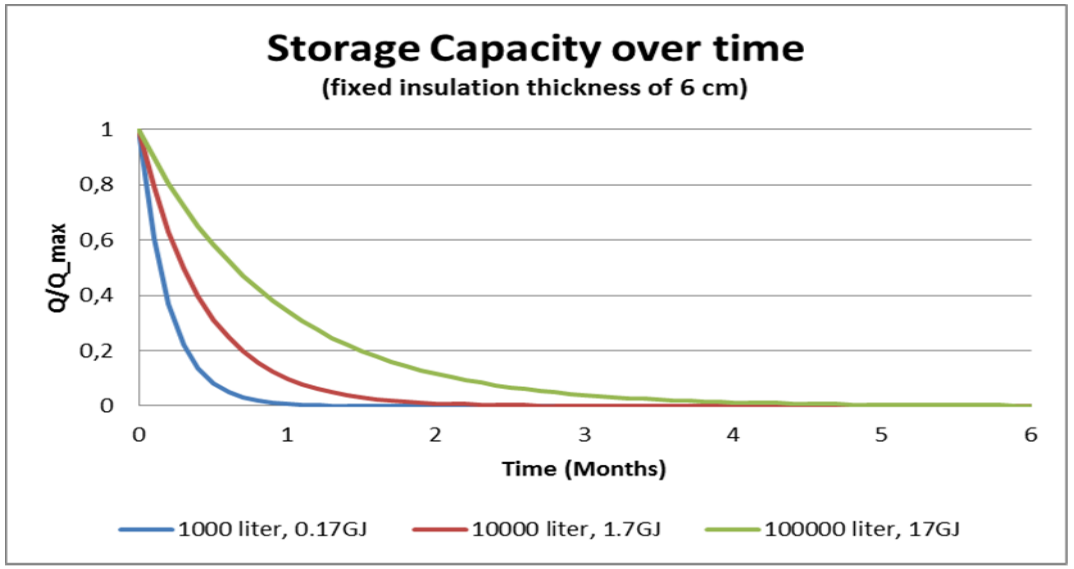


STORAGE ON BUILDING OR DISTRICT LEVEL



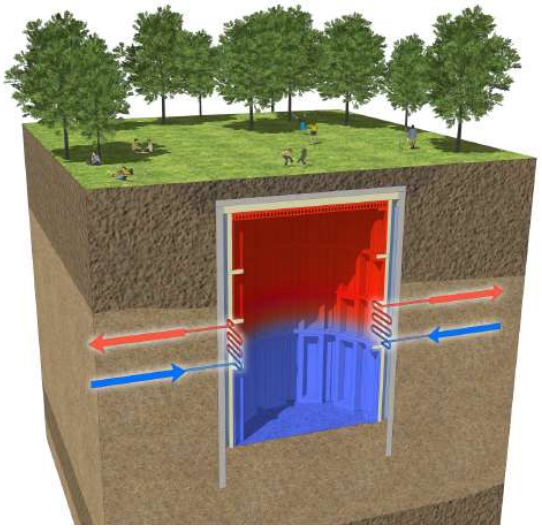


HOT WATER STORAGE TANK



EXAMPLES

5700 m3 heat store
2900 m2 solar thermal, Munich 2007

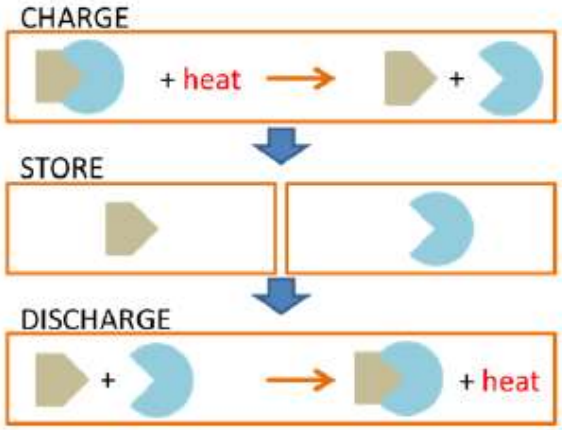


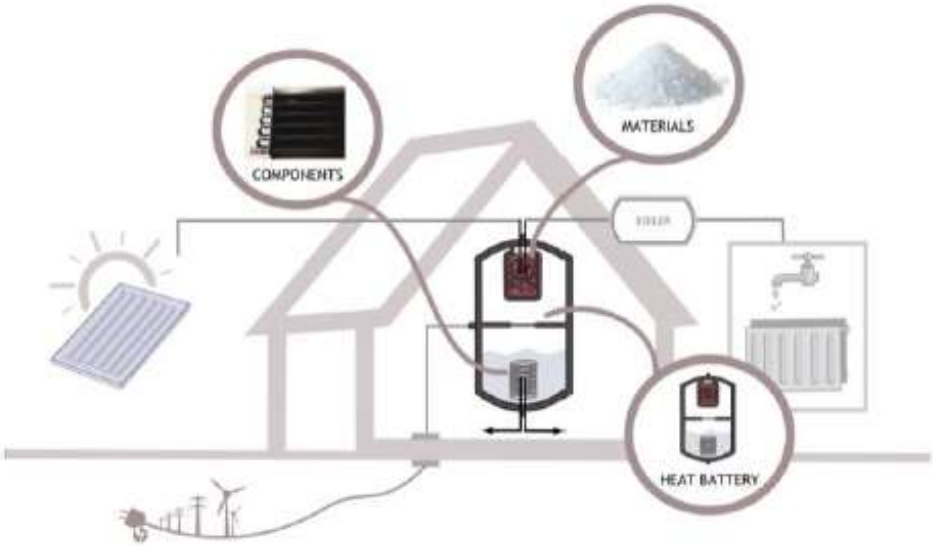
ECO vat (NL, under development)

EXAMPLE: Denmark, Vojens

200.000 m3, operational since 2016. City with 7,655 inhabitants (50 MW_{th}; 55 – 60 % heating demand)

HEAT STORAGE – HEAT BATTERY





TCS Storage density material → component → system

Materials

Components

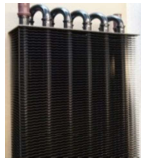
System

Q/V=2.9 GJ/m³

Salt hydrate

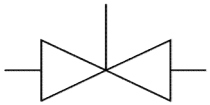
Stabilized packed bed

Store process water

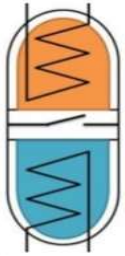


Heat Exchanger with Salt Hydrate

Evaporator / condensor



Internal Valve

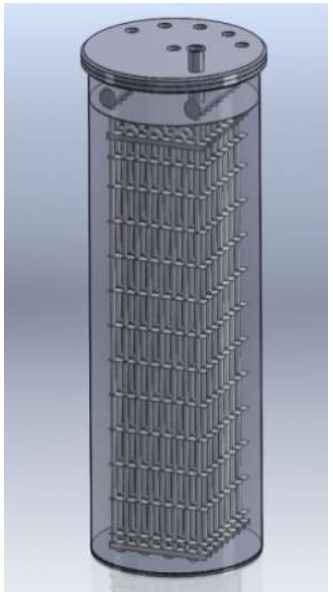


Fit factors, tubing and free space

Insulation included

Q/V (target)
~ 1 GJ/m³

THERMO-CHEMICAL HEAT BATTERIES



THERMO-CHEMICAL HEAT BATTERIES

Motor operated valve reactor side

Motor operated valve E/C side

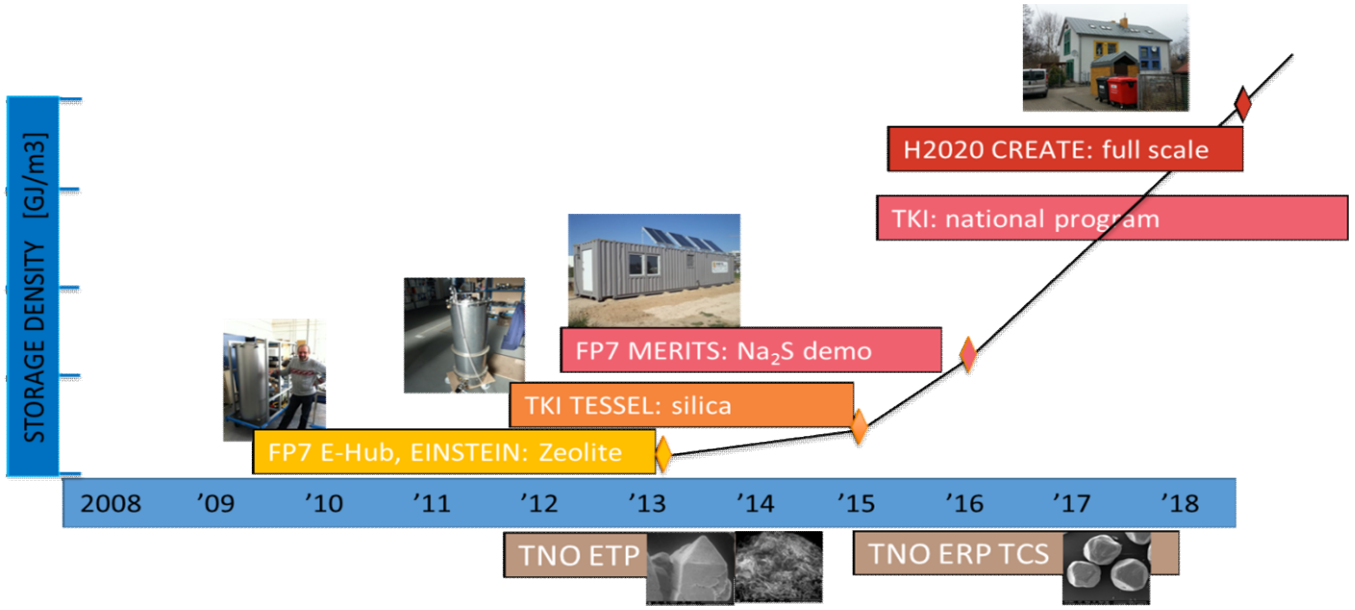
Motor operated Internal valve

Pressure sensor and manual operated valve

Seasonal thermal battery

- Capacity demo: ~0.2 GJ/m^3
- Modular: 8 modules
- Fixed bed, vacuum system
- TCM material: Na_2S
- Currently @ TNO, Delft
  (~ 0,5 GJ (135 kWh) capacity)

EVOLUTION OF KPI: ENERGY DENSITY



MJP - COMPACTE CONVERSIE & OPSLAG

TNO innovation for life

OXYCOM SUSTAINABLE AIR CONDITIONING

DOW

HOGESCHOOL UTRECHT

itho daalderop Climate for life

CCS energie-advies

Wendelin

alliander

TU/e

De Beijer RTB B.V

DWA installatie- en energieadvies

Hanzehogeschool Groningen University of Applied Sciences

COMSOL MULTIPHYSICS

NEDMAG INDUSTRIES

Universiteit Twente de ondernemende universiteit

Liveliness

bjw duurzaam wonen

TU Delft Delft University of Technology

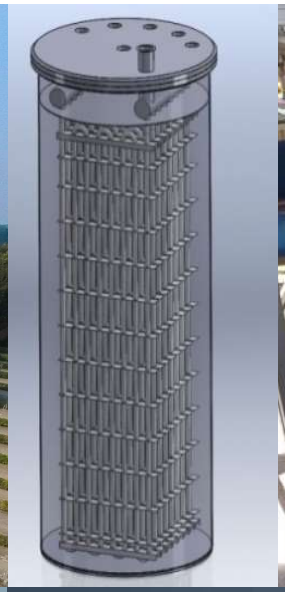
LOSS FREE HEAT STORAGE (HEAT BATTERY)

https://youtu.be/FZu2qDeOqFQ

FINAL REMARKS / DISCUSSION

- Long term (seasonal) storage needed for large scale integration of renewable energy (decoupling supply – demand)
- Different kinds of (seasonal) heat storage possible, choice depending on local conditions:
  - Individual solutions (dwelling/building level)
  - Cooperative solutions ((semi-) large scale storages, potentially combined with local micro-grids)
- Economic viability (> 20 years lifetime, no/low maintenance) and system integration important development topics

Energy production



Long term storage

Minimising use

Positive energy balance