MERITS

More Effective use of Renewables including compact seasonal Thermal energy Storage

ENER/FP7/295983/MERITS

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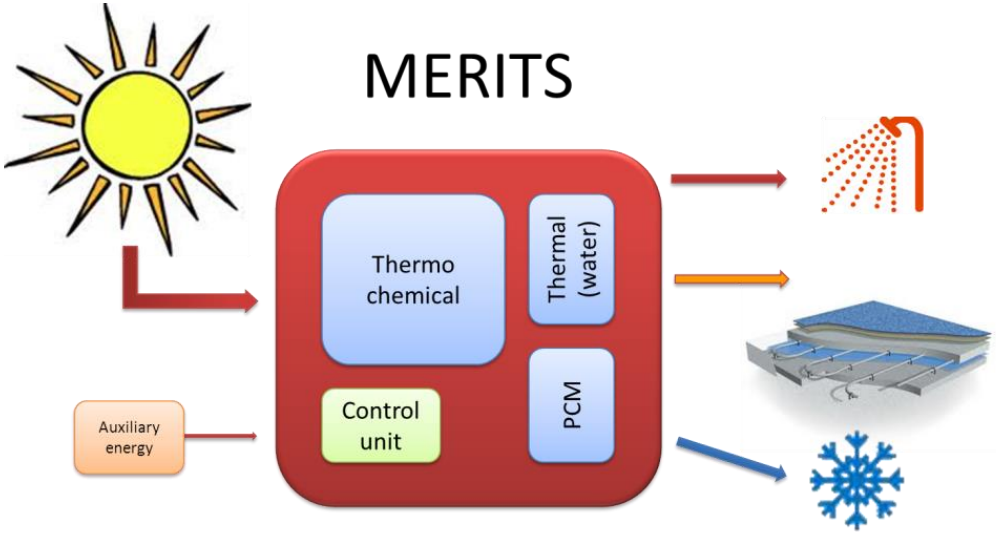

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EU ambition

- Energy neutral built environment in 2050
- Proposed measures: *trias energetica*

  1) Lower energy use, decrease losses

  2) More renewable energy

  3) More efficient use of fossil energy

- Built environment
  - Passive measures: compact building, insulation!
  - Active measures: PV, thermal, wind, water
  - Heat pumps, low T heating, efficient system lay-out (short pipes etc.)

- Through the thermal battery developed within MERITS the renewable energy harvested in summer is available throughout the year!


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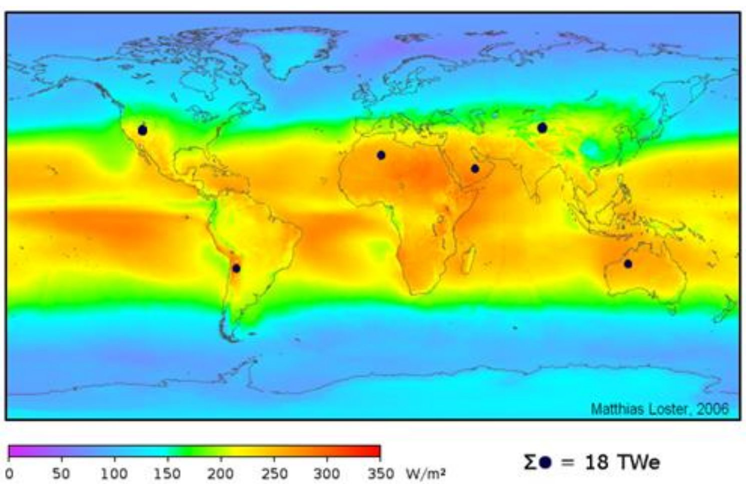
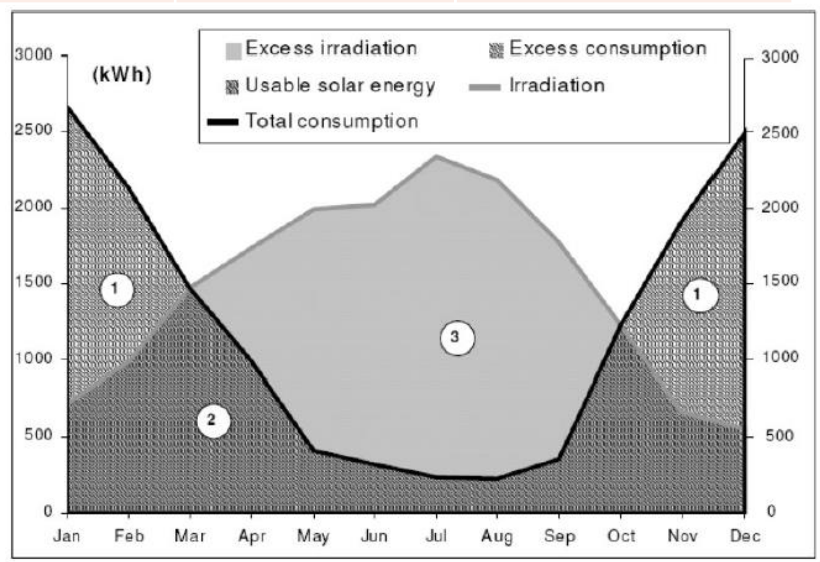
Rationale: Why seasonable energy storage?

- Solar energy suffices & highest potential for sustainable future
- In NL → 110W/m² (year average) only 3 times below maximum(!)
- But low intensity when most needed in winter
- → Seasonal storage!

	Utilization 2005 [EJ]	Technical potential [EJ/yr]
Biomass	46.3	160 - 270
Geothermal	2.3	810 - 1545
Hydro	11.7	50 - 60
Solar	0.5	62,000 - 280,000
Wind	1.3	1250 - 2250
Ocean	-	3240 - 10,500

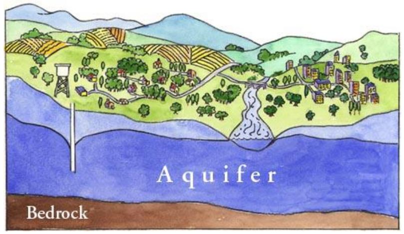


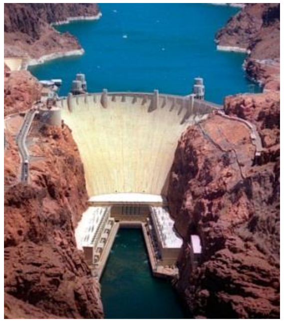


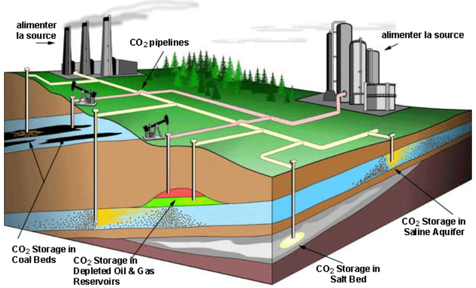
Ways of energy storage

- Sensible heat (boiler, borehole)
- Latent heat (PCM)
- Thermochemical (e.g. silica gel, zeolite, salt hydrates)

- Electrochemical (batteries)
- Gravitational (artificial lake)
- Pressurized air (e.g. underground)
- Bio-fuel (e.g. sugar cane)
- …



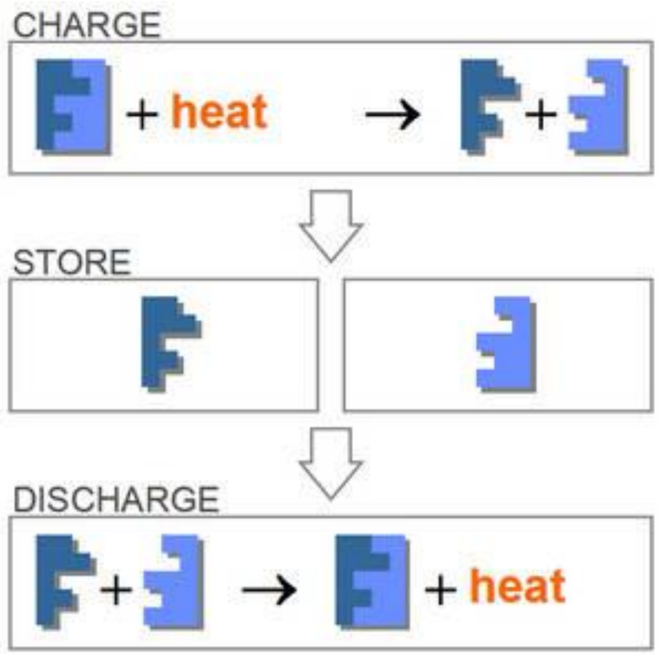




1 year’s worth of thermal energy per household (52 GJ; year 2000)

- 1.4 m^3 crude oil (36 GJ/m^3)
- 1.6 m^3 gasoline (32 GJ/m^3)
- 2.4 m^3 (bio)ethanol (22 GJ/m^3)
- 2.5 m^3 coal (20.5 GJ/m^3)
- 10 m^3 wood (5.4 GJ/m^3 , RV_{wood} = 20%)
- **17 m^3 Na_2S (3 GJ/m^3)**
- **18 m^3 $CaCl_2$ (2.8 GJ /m^3)**
- 43 m^3 Ni-MH battery (1.2 GJ/m^3)
- 43 m^3 H_2, 100 bar (1.2 GJ/m^3)
- **104 m^3 sodium-acetate tri-hydrate (PCM) (0.40 GJ/m^3)**
- 144 m^3 lead-acid battery (0.36 GJ/m^3)
- **210 m^3 water with ΔT = 60 °C (0.25 GJ/m^3)**
- 577 m^3 vanadium – redox battery (0.09 GJ/m^3)
- 1500 m^3 methane (0.035 GJ/m^3)
- 2100 m^3 groundwater with ΔT = 6 °C (0.025 GJ/m^3)
- 4377 m^3 H_2, 1 bar (0.012 GJ/m^3)


What is thermochemical storage? (adsorption / absorption)



Source: ECN, the Netherlands

Loading:

$CaCl_2 \cdot 6H_2O$ + heat → $CaCl_2 \cdot 2H_2O + 4H_2O$

Storage:

$CaCl_2$ separate from H_2O

Unloading:

$CaCl_2 \cdot 2H_2O + 4H_2O$ → $CaCl_2 \cdot 6H_2O$ + heat

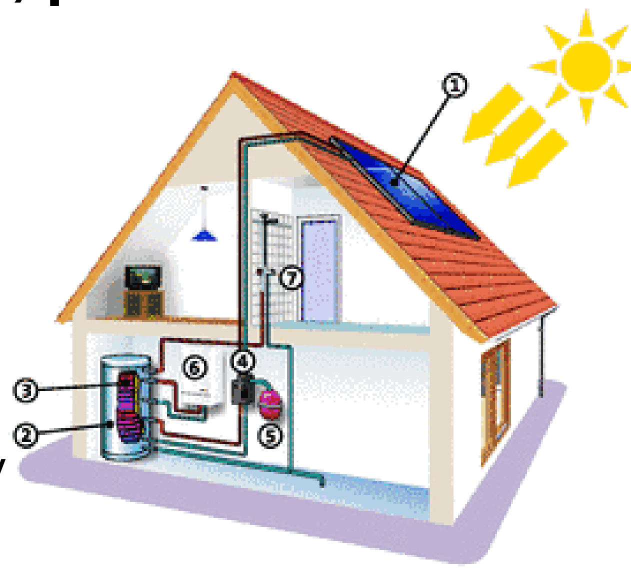
Thermochemical storage materials

	Advantages	Disadvantages
Adsorption (silicagel, zeolite, …)	Physically stable	Low E/V, T-generation
Absorption ($CaCl_2$, $MgCl_2$, Na_2S, …)	High E/V, T-generation	Corrosivity, cyclability, stability
Other (Metal oxides, hydrides, solutions, suspensions)	Various (e.g. high E/V, liquid, easily pumpable)	Various (e.g. TRL is low, corrosivity, high T's, P's needed)

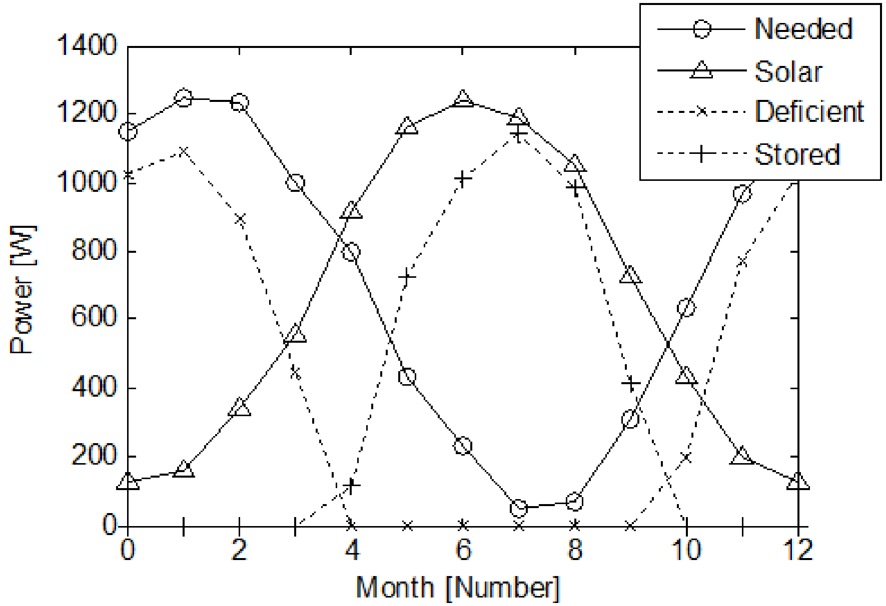
- Choice of material depends on
  - Available temperature for charging & working temperature for discharging
  - Safety & toxicity (H_2S (g), NH_3 (g))
  - Instrumentation & costs (available space, high pressure / vacuum)

Case – Thermochemical storage, passive house

- Heating demand 2020: 20GJ/year (prognosis continental climate)
- Storage for cold season 10GJ
- TCM volume ~10m^3 (~1GJ/m^3)
- Solar collectors ~17m^2 (~1.2GJ/m^{2}y)
- Solar boiler for short term storage & delivery



Source: Solarpraxis AG



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MERITS overview & goals – Rechargeable heat battery

- To develop, demonstrate and evaluate a compact seasonal thermal storage system based on novel high-density materials that can supply the required heating and cooling in houses with up to 100% renewable energy sources…

- … with the aim of market introduction within reasonable time afterwards.

- Renewable energy supply – collectors
- Materials, components, system – hardware
- Control strategy for loading/unloading – software

→ Demonstration!

 

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Previous projects of consortium partners

- MODESTORE
- HESTOR
- HYDES
- MESSIB
- PREHEAT
- E-Hub
- EINSTEIN

→ Large potential of solar energy demonstrated
→ Modeling of systems/components on-going
→ Compact sorption storage demonstrated
→ PCM’s development on-going
→ Sorption materials research on-going
→ Integration in system addressed
→ Training activities organized
→ Public awareness increased
→ Seasonal storage within range

- MERITS: the next step!

  → enhanced materials

  → enhanced reactor set-up

  → seasonal storage to be demonstrated across EU

The · on the horizon

- Seasonal thermal energy storage for 1 family house
- Challenges:
  - Compact (4-8m^3), minimize losses
  - Multiple T's: tap water, space heating, cooling
  - Safe, reliable, sustainable
- 3 main developments:
  - Energy supply: Solar collectors
  - Energy storage: Storage materials & components
  - Energy delivery: System design & integration
- Main task:
  - To demonstrate new and effective thermal energy storage technology as prototype as part of a overall system concept

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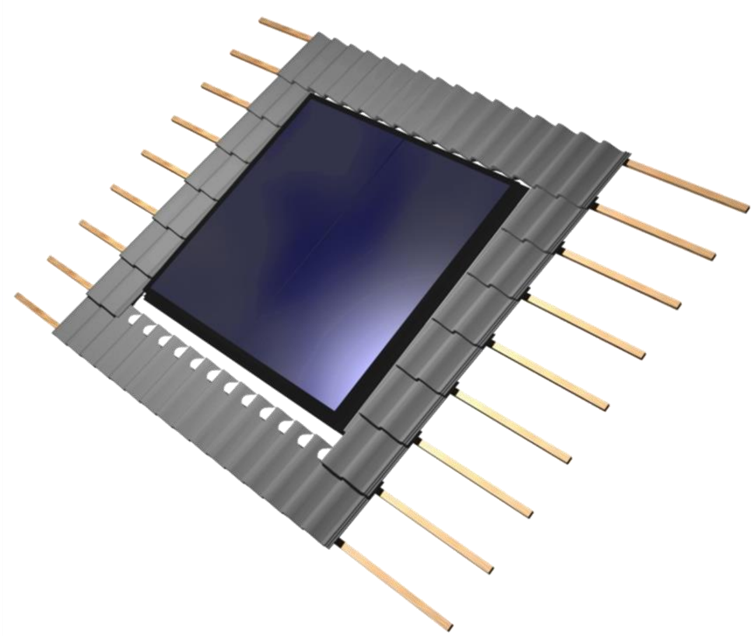
3 main developments

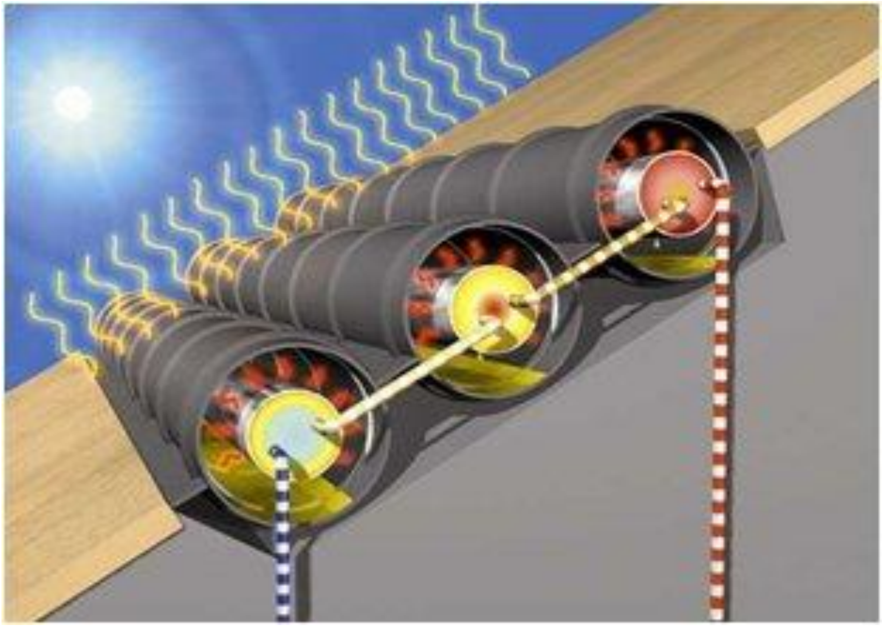
- Renewable Energy Supply: Solar collectors + integration of storage
- Energy storage: Enhanced materials, reactor + components
- Energy delivery: System integration

3 main developments

- **Renewable Energy Supply: Solar collectors + integration of storage**
- Energy storage: Enhanced materials, reactor + components
- Energy delivery: System integration



Source: ZEN BV, the Netherlands

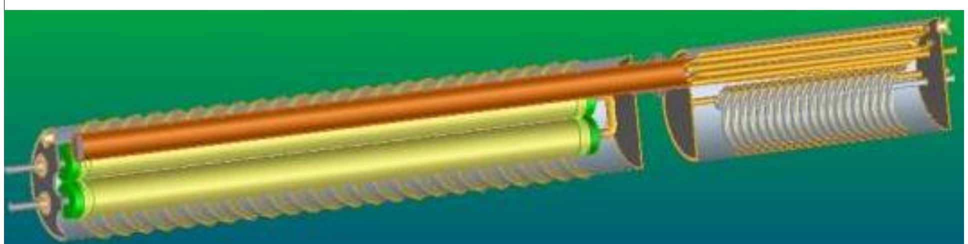


Source: De Beijer RTB BV, the Netherlands

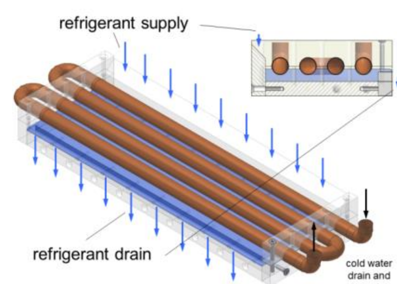
Pictures are examples as developed in previous projects

3 main developments

- Renewable Energy Supply: Solar collectors + integration of storage
- **Energy storage: Enhanced materials, reactor + components**
- Energy delivery: System integration





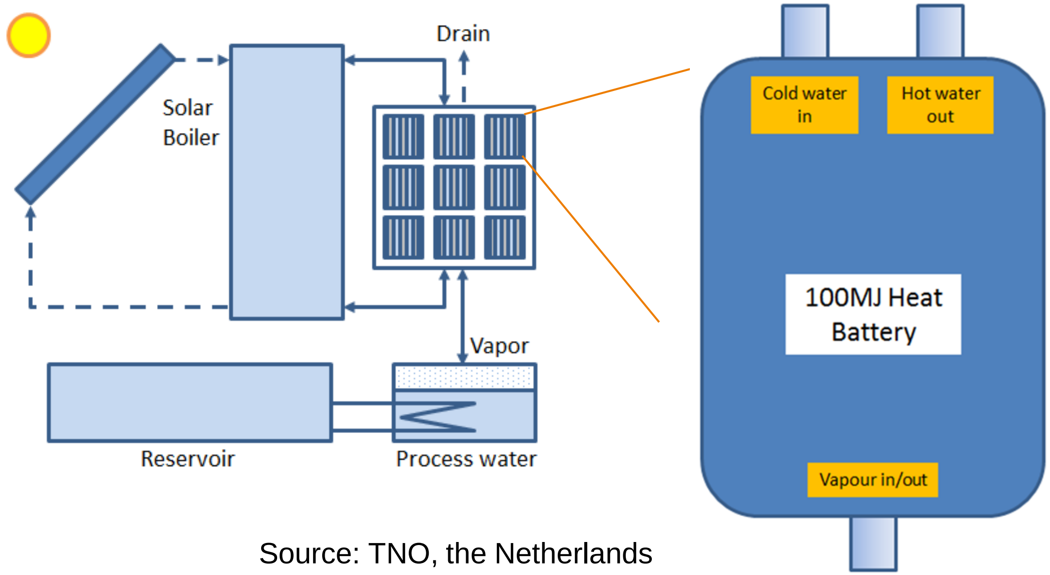


Sources: TNO & ECN, the Netherlands; Fraunhofer ISE, Germany

Pictures are examples as developed in previous projects

3 main developments

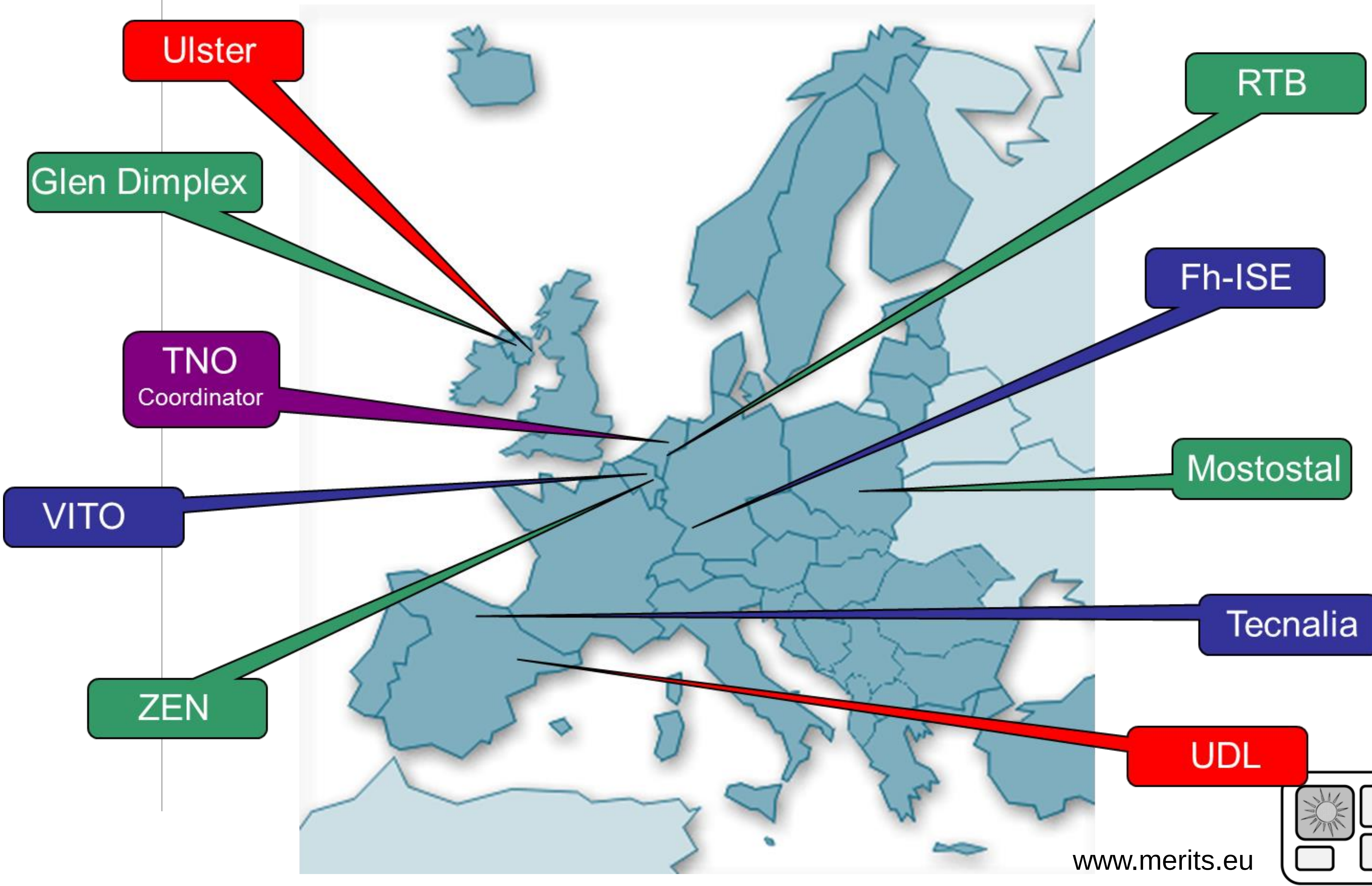
- Renewable Energy Supply: Solar collectors + integration of storage
- Energy storage: Enhanced materials, reactor + components
- **Energy delivery: System integration**



Source: TNO, the Netherlands


Main results - detail

- Specification of Seasonal Storage System (WP2)
- Solar collector prototype & test results (WP3)
- Characteristics of new/modified TCM and PCM material: input data for model (WP4)
- Computer model of energy storage sub-system (WP4)
- Production of Prototype energy storage sub-system; lab tested (WP4/5)
- Blue-print of overall energy system design, including control (WP5)
- Report on the overall energy system: demonstration and field test results for various climatic zones (WP6)
- Report on market analysis and business model (WP7)
- 3 peer reviewed papers + 1 patent (WP8)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Glen Dimplex
TNO
Coordinator
VITO
ZEN
RTB
Fh-ISE
Mostostal
Tecnalia
UDL

Industry Platform

- Advisory body for MERITS consortium
  - Stream-line research towards usable products
  - Align project results with reference market needs
  - Suggest appropriate routes towards market up-take

→ Guarantee adoption of results by industry

- Members are selected on the basis of recommendation by consortium
- MERITS industry partners chair Platform
- Each geographical area has local Platform-meetings
- Platform kick-off: last March
- End of project: workshop for dissemination of final project results

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Timeline

2012

Oct 1 2012 - now: Specification of Seasonal Storage System, requirements

2013

1st half 2013: Collector improvement, material selection, preliminary system design

2nd half 2013: Demonstration of cooling system, component & material testing

2014

2014: Detailed system design, implementation of enhanced materials & components for lab-demonstrator

2015

Early 2015: Manufacturing of 3 demonstration set-ups

From 2015: Demonstration across EU (UK, Poland, Spain)

2016

Oct 2016: end of project

2017

FP7 projects: cooperation!

- MERITS: 1 of 4 compact thermal storage projects funded
- Similar developments, similar problems!
  - Exchange of knowledge / progress
  - Exchange of solutions
- → periodic meeting between the projects?
  - Open for discussion

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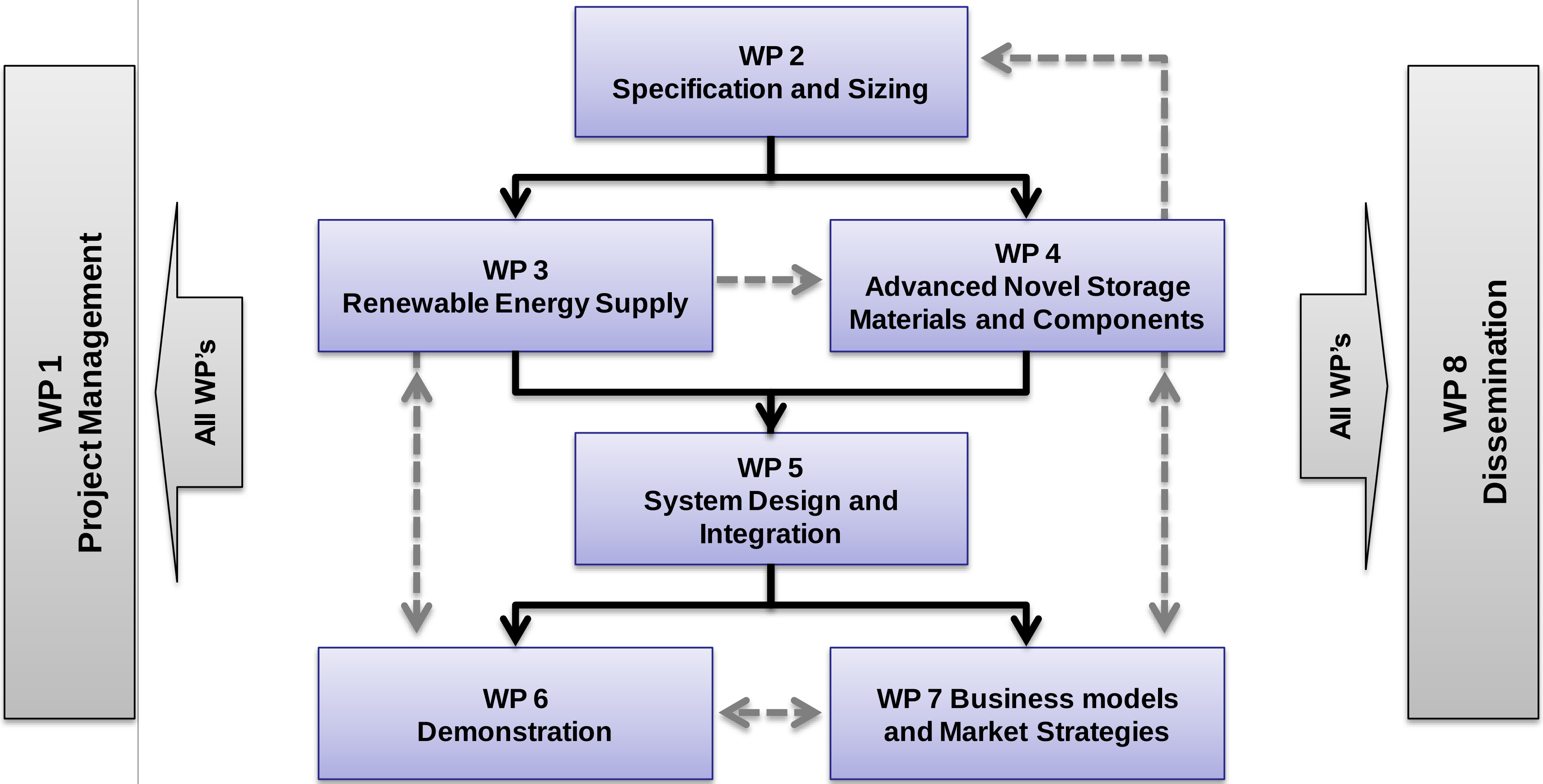
From here: backup slides

Interaction between WP's



Work packages

Work Package	Goal	WP Leader
WP1 - Project Management	Deliverables on time, Solve contractual or IPR issues, Document control on Sharepoint, MERITS point of contact	TNO (Christophe Hoegaerts)
WP2 - Specification and Sizing	Define the Boundary Conditions of the MERITS Systems, definition of specifications	Ulster (Philip Griffiths)
WP3 - Renewable Energy Supply	Characterisation, optimization, building and test of renewable energy technology, i.e. solar collector for MERITS system	TNO (Bart de Boer)
WP4 - Advanced Novel Storage Materials and Components	Selection of novel advanced materials, component (e.g. evaporator/condensor) and storage system development and lab test	UDL (Luisa F. Cabeza)
WP5 - System Design and Integration	Effective integration and lab testing of the MERITS storage system (building integration, (dis)charging, thermal output, control)	Tecnalia (Carol Pascual)
WP6 - Demonstration	Field test of 2 existing systems (o.a. Solabcool) and MERITS system (for 3 climate zones)	Ulster (Philip Griffiths)
WP7 - Business Models and Market Strategies	Pave the way for market introduction of MERITS system (market needs, business models, relevant rules and standards)	RTB (Rob ter Steeg)
WP8 - Dissemination	Disseminate project results to outside world	Fraunhofer (Gerrit Füldner)

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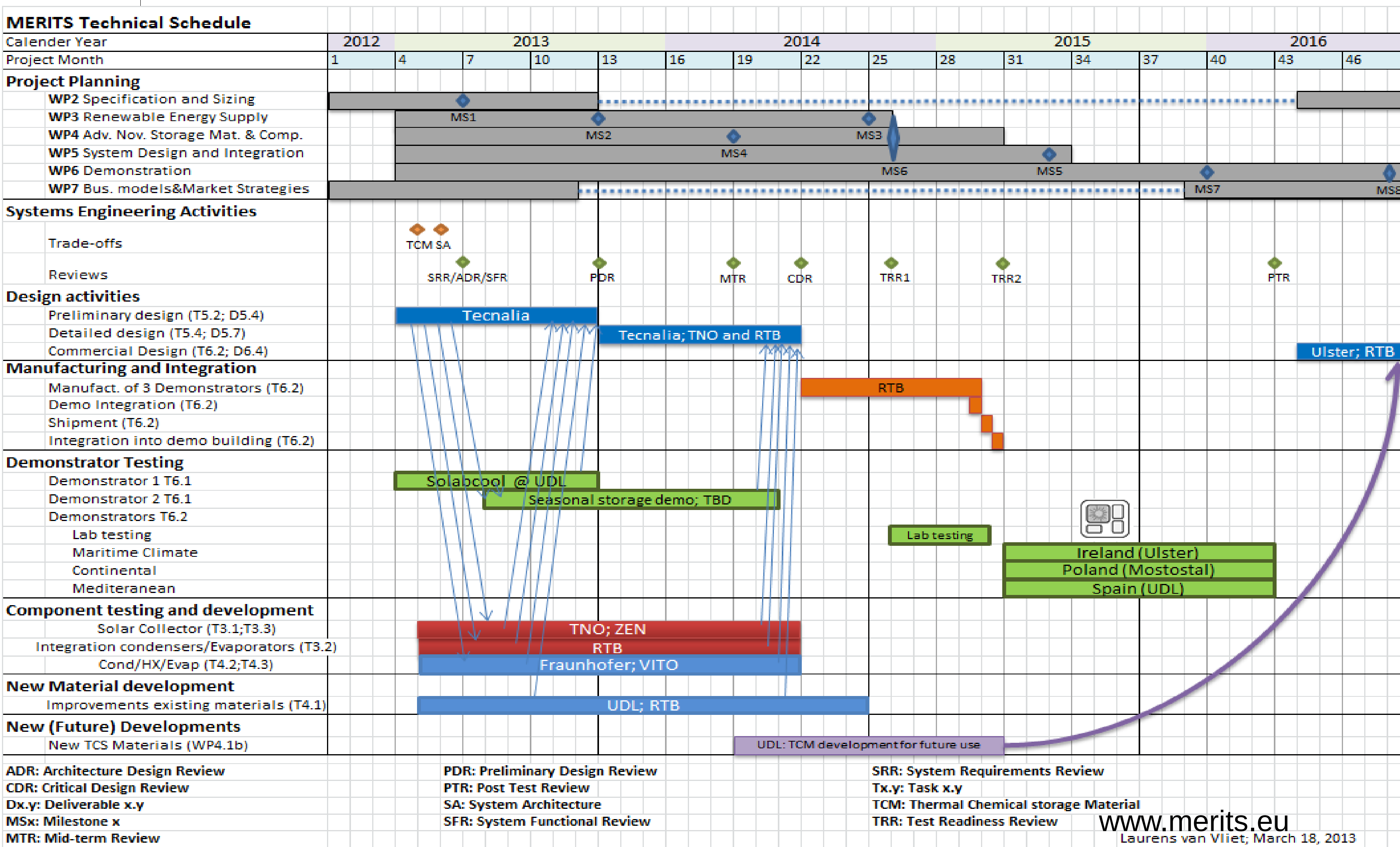
SE planning



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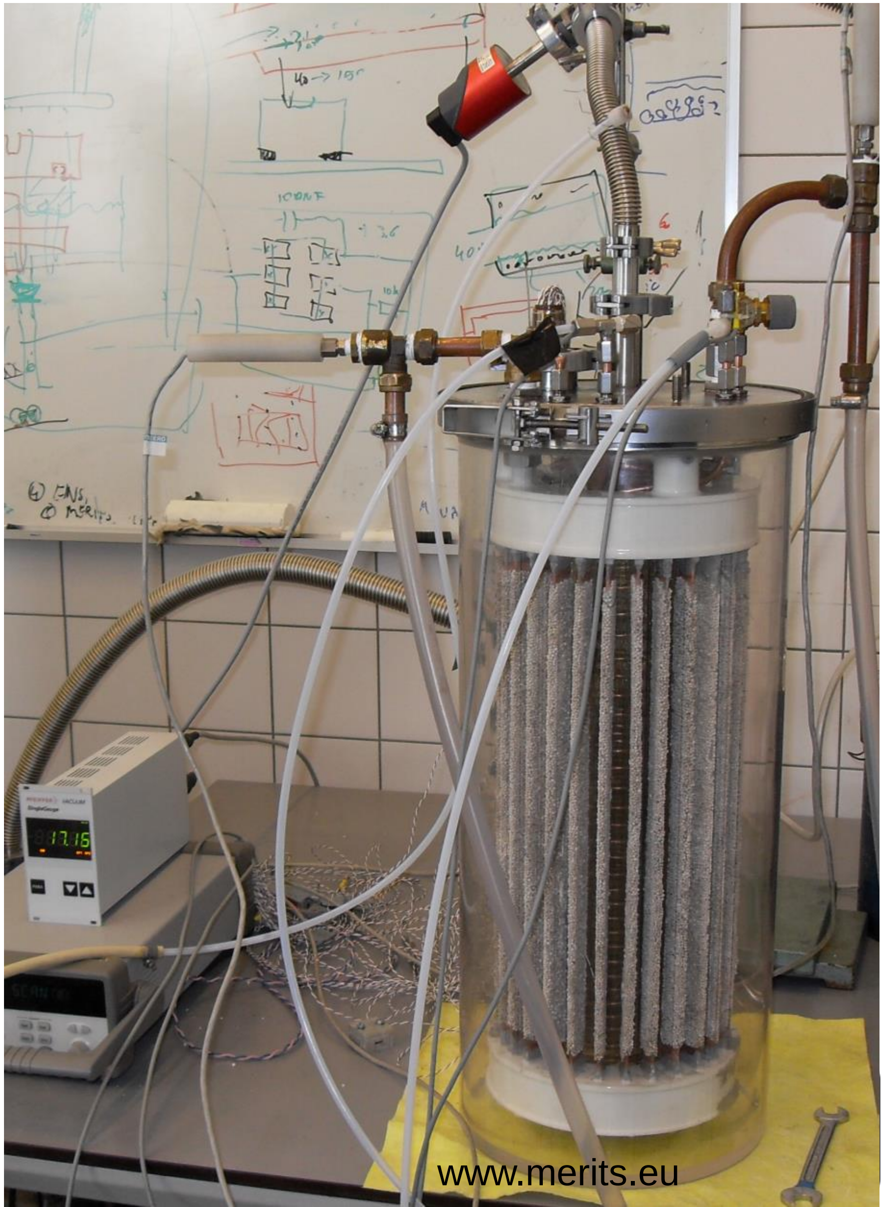
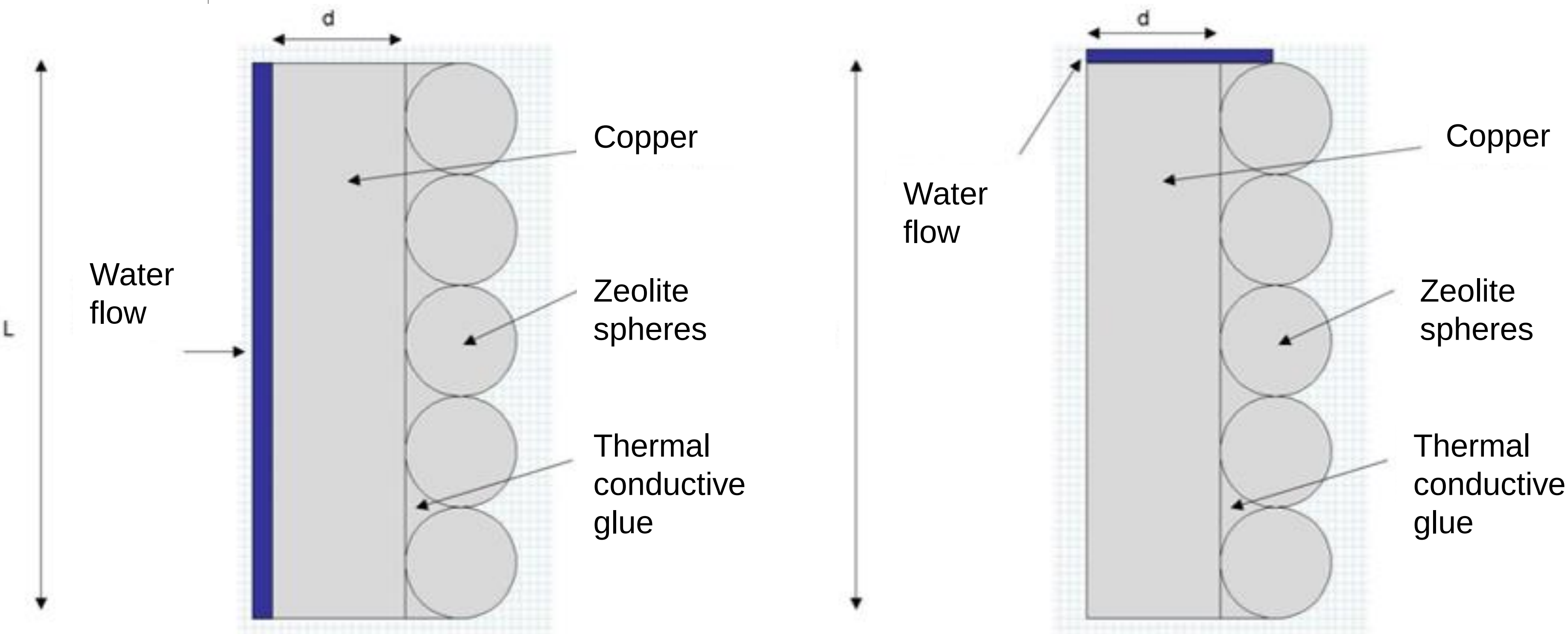
Experimental

- Working vacuum demo-reactor
- Good thermal contact
  - Evap/cond.
  - Ads/des.
- Fast mass-transport

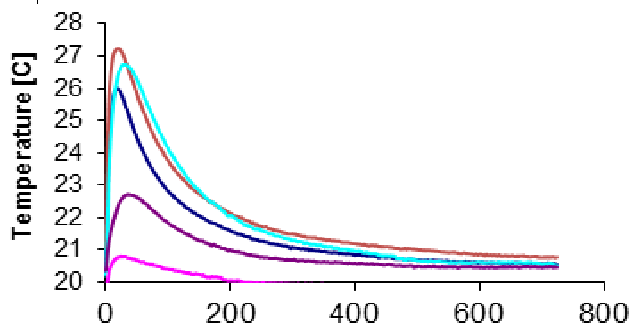


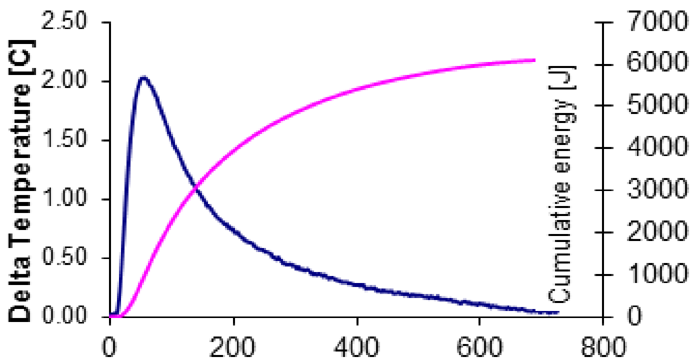
Modeling

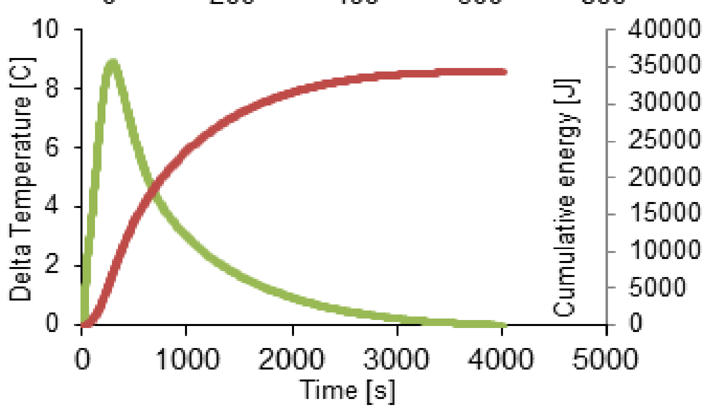
- Comsol



Experimental results







- Very fast reaction times (3 – 5 mins)
- ΔT(zeo) ~ 7 °C

- Moderate Temperatures
- ΔT(out-in) ~ 2 °C

- Thicker layers
- Slower reaction times (10 – 20 mins)
- ΔT(out-in) ~ 9 °C

- 0.60 kW/kg specific output power
- 0.3 GJ / m^3 specific capacity

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