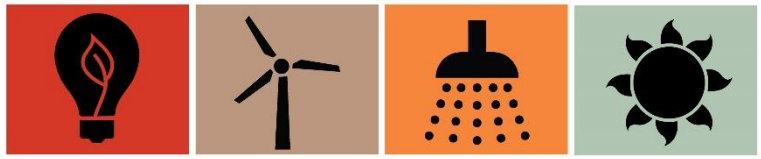
This project is supported by the European Commission under the Grant Agreement number: 680450.

SP18

CREATE©



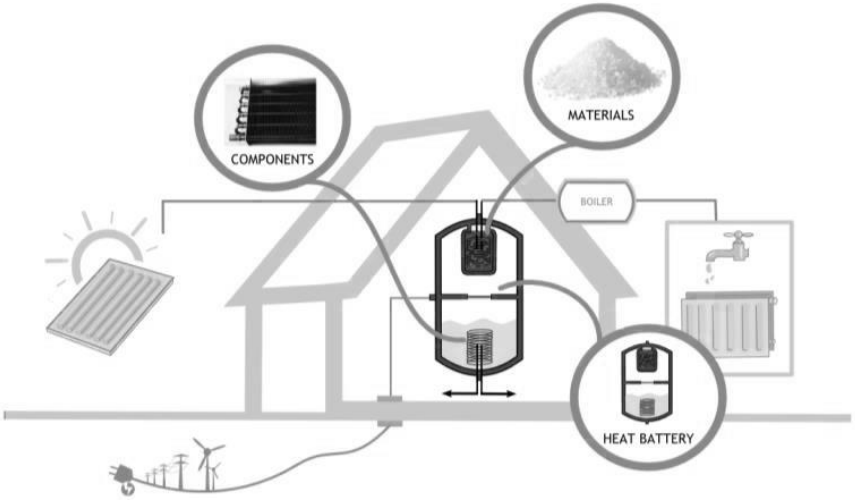
# Compact Retrofit Advanced Thermal Energy Storage

AEE INTEC

Rebekka Köll, Wim van Helden, Samuel Knabl

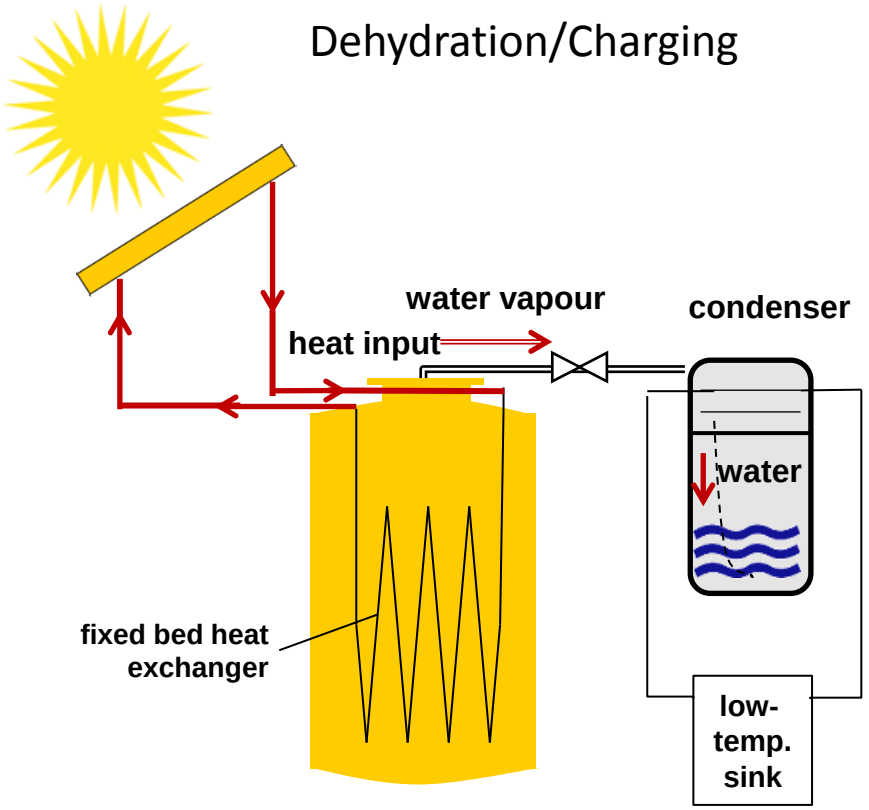
# Objective

- EU H2020 project – 4 years (2015-2019)
- Develope and demonstrate a thermal energy storage system based on TCM
  - Economic affordable
    - Energy Savings
  - Compactness
    - High Energy Density
    - Compact Construction
  - No losses during heating

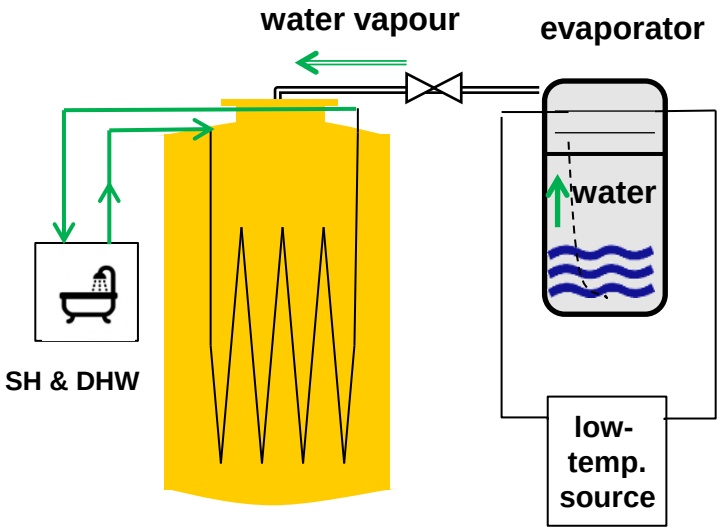


# Dehydration/Hydration Process

Dehydration/Charging




Hydration/Discharging



# Requirements on Developments

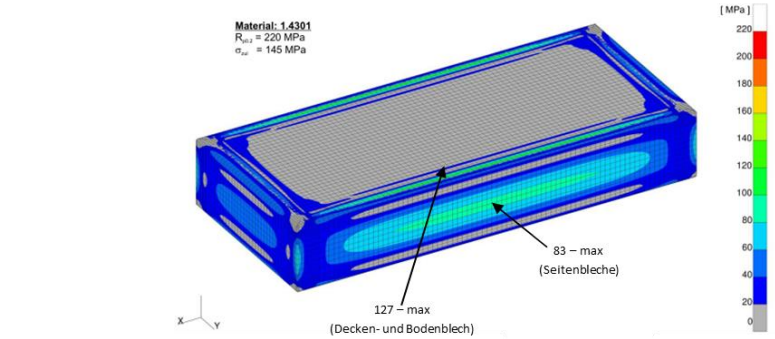
- Storage Material
  - Reversible charging/discharging
  - High energy density
  - Suitable extraction power
  - Long term multi-cycle stability
  - No outgassing
- Critical components
  - Absorber HX - suitable power, no corrosion
  - Absorber Module – withstand vacuum forces, no corrosion, compact (prismatic shape to save 27 % of lost space)
  - E/C (low cost, sufficient power, simple construction)

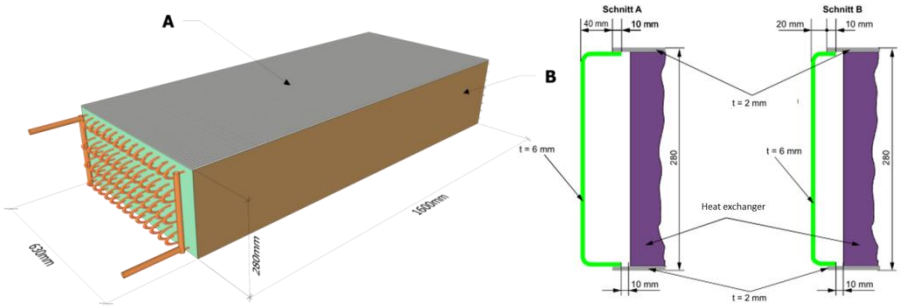
# Storage Material

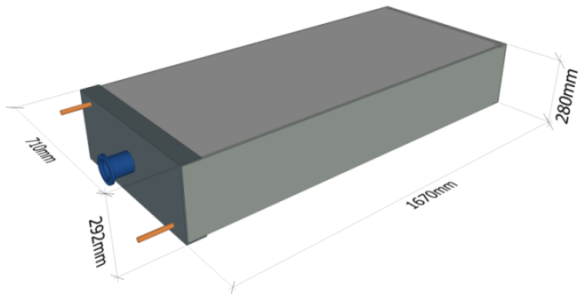
- $K_2CO_3$ – potassium carbonate
- Added 3 % grafite – improve stability
- Bimodel grains
- Outgasing tested – within limits

# Absorber development

- Compact prismatic design for 250 litres of K2CO3
- Fin - Heat exchanger function as structural element
- FEM– calculations of the absorber HX and the containment showed realizability



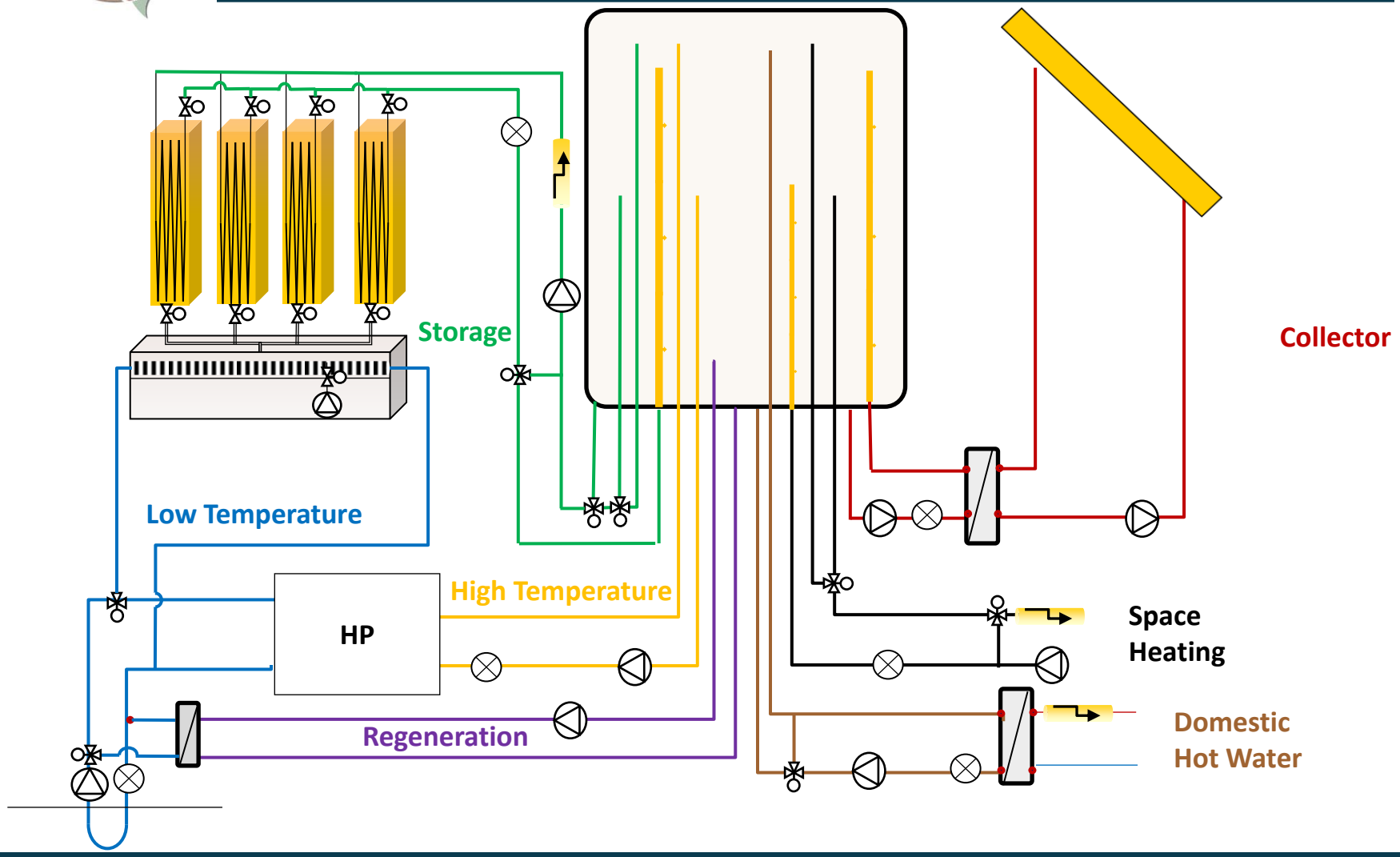



# Heat battery / Testing

- 1 kg Tests
  - Small scale tests to get first knowledge about kinetic and validate simulation model
- Module tests (250 l)
  - Test single module in real scale
- System Test ( 1 000 l)
  - Test complete storage system with 3-4 modules
- Demonstration in Poland
  - Integrate storage system in house in Warsaw and demonstrate over several months – automated control

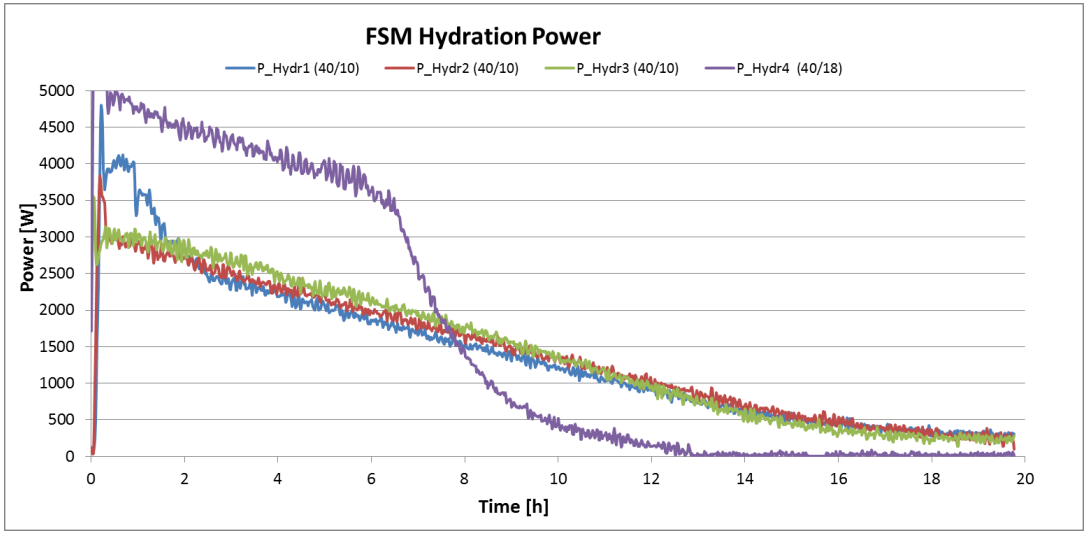
# System design for demonstration



# Lab test rig


Heating rod
Evaporator / Condenser
Puffer storage
Storage module
Scale
CREATE
CREATE

# Hydration




| | Duration | Power | Energy |
|---|---|---|---|
| 1. Hydration 40/10 | 23 h | 1235 W (ext)<br>769 W (evap) | 122 kWh/m³<br>0.439 GJ/m³ |
| 2. Hydration 40/10 | 21 h | 1410 W (extr)<br>830 W (evap) | 122 kWh/m³<br>0.439 GJ/m³ |
| 3. Hydration 40/10 | 21 h | 1470 W(extr)<br>900 W (evap) | 124 kWh/m³<br>0.447 GJ/m³ |
| 4. Hydration 40/18 | 12 h | 2670 W(extr)<br>1800 W (evap) | 143 kWh/m³<br>0.515 GJ/m³ |

# Dehydration

| | Duration | Power | Energy |
|---|---|---|---|
| 1. Dehydration 100/10 | 24 h | 1900 W (input)<br>1100 W (cond) | 121 kWh/m³<br>0.437 GJ/m³ |
| 2. Dehydration 90/10 | 48 h | 1900 W (input)<br>non-condensables | 121 kWh/m³<br>0.437 GJ/m³ |
| 3. Dehydration 80/10 | 96 h (4 days) | 1900 W (input)<br>Non-condensables | 123 kWh/m³<br>0.442 GJ/m³ |

# Comparison Dehydration

- Time:
  - 100 °C: 24 hours
  - 90 °C: 48 hours
  - 80 °C: 96 hours
- Condensation Power: 1100 W
- Mass difference 31 kg
  - Aim 38.6 kg → 80 % of storage capacity
- Energy: 31 kWh → **124 kWh/m³ or 0.447 GJ/m³**
- Good kinetics → but outgassing observed during/after desorption

# Comparison Results

| | FSM (40/10) | CSM | |
|---|---|---|---|
| m_hydr | 236 | 1387 | kg |
| Free volume in module | 252 | 1256 | dm³ |
| Density in free volume | 0,94 | 1,1 | kg/dm³ |
| | | | |
| Energy | 101 | 691 | GJ |
| | 28 | 192 | kWh |
| Power output | 1479 | 2467 | W |
| Spec. heating power | 5,9 | 5,9 | W/dm³ |
| Energy density (based on free volume of the HX) | 450 | 550 | MJ/m³ |
| | 124 | 153 | kWh/m³ |
| Energy density (based on full system ) $S_{eff}$ | | 77 | kWh/m³ |

**Physical storage density $S_{phys}$**

Bulk volume of storage material

**Effective storage density $S_{eff}$**

Volume of the box with rectangular footprint and one height into which all modules and auxiliary components fit

# Conclusion

- Multiple cycles were carried out successfully
- Power output with **1479W** is 40 % lower then the goal of 2500W
- Absorbed water mass in the avg. **31kg** – theoretical max is **38,6kg** (80 %)
- Increase performance of final demonstration system
  - Power – increase module size – HX area
  - Energy denstiy – higher bulk density due to improved filling procedure
- Non-condensable gases during dehydration detected which blocked the condenser – outbaking proceedure
- Tests are being continued


# Thank you for your attention