**PROBLEM STATEMENT**

- Solar energy suffices & highest potential for sustainable future, but imbalance in supply and demand of heat
- Thermal energy storage is the solution enabling widespread and integrated use of Renewable Energy Systems

<table>
<thead>
<tr>
<th></th>
<th>Utilization 2005 (EJ)</th>
<th>Technical potential (EJ/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass</td>
<td>46.3</td>
<td>160 - 270</td>
</tr>
<tr>
<td>Geothermal</td>
<td>2.3</td>
<td>810 - 1545</td>
</tr>
<tr>
<td>Hydro</td>
<td>11.7</td>
<td>50 - 60</td>
</tr>
<tr>
<td>Solar</td>
<td>0.5</td>
<td>62,000 - 280,000</td>
</tr>
<tr>
<td>Wind</td>
<td>1.3</td>
<td>1250 - 2250</td>
</tr>
<tr>
<td>Ocean</td>
<td>-</td>
<td>3240 - 10,500</td>
</tr>
</tbody>
</table>

Towards a sustainable world and energy efficient built environment

20 % reduction of CO₂ emission by 2020 and 85 % by 2050

Heat storage as indispensable enabler

Christophe Hoegaerts
Development of a thermo-chemical heat battery

**MERITS PROJECT USE CASE – SEASONAL STORAGE OF SOLAR ENERGY**

- Total roof collector heat suffices for space heating of dwellings
- If excess heat in summer is stored for later use in winter
- E.g. 10GJ storage $\rightarrow$ $\sim$10m³ system $\rightarrow$ $\sim$1GJ/m³ guideline

![Diagram of seasonal storage system]

**BIGGEST CHALLENGES FOR THERMAL STORAGE**

- **Cost effectiveness:** economically feasible on the long term
- **Energy density:** achieving an acceptable size

$\rightarrow$ MERITS demonstration targets precisely these issues!

Click [here](#) for the latest MERITS promotional video (April 2016)
Development of a thermo-chemical heat battery

STORAGE PRINCIPLE OF MERITS

- For MERITS, **Na$_2$S** as thermochemical storage material (TCM).
- **Na$_2$S**: cheap hygroscopic salt, reversible reaction:

  \[ \text{Na}_2\text{S} \cdot 5\text{H}_2\text{O} + \text{heat} \leftrightarrow \text{Na}_2\text{S} \cdot \frac{1}{2}\text{H}_2\text{O} + 4\frac{1}{2}\text{H}_2\text{O} \]

- Material Storage Density $\rightarrow$ 2.9 GJ/m$^3$
  
  (given reaction)

- Storage is in principle **loss free**!

MERITS SYSTEM & COMPONENTS

[de Boer 2003]

[de Jong 2015]
Development of a thermo-chemical heat battery

**MERITS: AREAS OF RESEARCH**

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

**MERITS FIELD TEST DEMONSTRATOR**

- Complete storage system and building simulation compartment in a 45ft container
- System demonstrated in Lleida (without TCS)
- Demonstration in Warsaw on-going (with TCS)

www.merits.eu

RC4GleisdorfSolar 9/6/2016

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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

MODULE CHARACTERISATION - POWER

Operation (30h per half-cycle):
- Discharge: $T_s = 52 \, ^\circ C \geq 500W$ for $>12h$ ($T_e = 10 \, ^\circ C$)
- Charge: $T_d = 80 \, ^\circ C$ for $30h$ ($T_c = 10 \, ^\circ C$)
- Discharge: $T_s = 52 \, ^\circ C \geq 500W$ for $>12h$ ($T_e = 10 \, ^\circ C$)
Development of a thermo-chemical heat battery

Conclusions:
- ~30 MJ of energy discharged
- 8.9 kg of water evaporated
  This is consistent with transition between 5 to 2 hydrate with enthalpy of (de-)hydration of about 3400 kJ/kg.
- Volume per module: 326 liter (including insulation)
  \( Q/V \approx 0.1 \text{ GJ/m}^3 \)
- For transition between 0.5 and 5 hydrate \( Q/V \approx 0.18 \text{ GJ/m}^3 \), which is better than hot water tank

CONCLUSIONS & OUTLOOK

- Compact long-term storage system for seasonal applications demonstrated successfully
  Demonstrated storage density ~100 MJ/m\(^3\) (~28 kWh/m\(^3\)) (module level; Td: 80; Te: 10; Tc:10; Ts:52 °C) using Na\(_2\)S.xH\(_2\)O
  First time: TCS application using solar collector temperatures for charging, with storage densities in order of sensible storage, without thermal losses

- Future outlook
  - Short term: 170-200 MJ/m\(^3\) achievable
  - 4 years from now: ~600 MJ/m\(^3\) (CREATE)\(^a\)
  - Long term: up to 1000MJ/m\(^3\) after complete system redesign\(^b\)

\(^a\): www.createproject.eu; \(^b\): de Jong 2015
SUCCESSFUL FIELD TEST
DEMONSTRATION OF SEASONAL
SOLAR THERMOCHEMICAL STORAGE

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