LoT-NET research focuses on the integration of low temperature (LT) networks with heat pumps and thermal storage technologies to maximise waste and ambient heat utilisation in low or zero-carbon heating and cooling solutions.

Research Challenge 2: To advance performance of novel thermal storage, heat distribution and capture systems.

- **WP2.1** Distribution medium or method: Thermochemical systems;

- **WP2.2** Storage: New composite thermochemical heat storage materials will be developed.
## Thermal Energy Storage

<table>
<thead>
<tr>
<th>Storage Type</th>
<th>Mechanism</th>
<th>Formula</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensible Heat Storage</td>
<td>Temperature changes, Water, Oil, Rocks etc.</td>
<td>$Q = V \rho C_p \Delta T$</td>
<td>Low cost, Reliable</td>
<td>Low storage density, Large volumes, Heat losses</td>
</tr>
<tr>
<td>Latent Heat Storage</td>
<td>Phase changes, Salts, Paraffins, Eutectic etc.</td>
<td>$Q = m h_m$</td>
<td>Medium storage density, Small volumes</td>
<td>Corrosion, Low heat transfer, Heat Losses</td>
</tr>
<tr>
<td>Thermochemical Storage</td>
<td>Chemical reactions, Solid/Liquid-Gas, Gas-Gas</td>
<td>$Q = X n_B \Delta H_r$</td>
<td>Medium/Long term storage, High storage density</td>
<td>Technical complexity, High costs</td>
</tr>
</tbody>
</table>

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Thermal Energy Storage

Thermochemical Storage

Latent Heat Storage

Sensible Heat Storage

Fig. 1. Energy density of high energy storage methods. [1]

Thermochemical Heat Storage

\[ A \cdot (m + n)B + \text{Heat} \quad \text{charging} \quad A \cdot mB + nB \quad \text{discharging} \]

**Fig. 2.** Chemical storage and sorption storage classification. [1]

**Fig. 3.** Charging, storing and discharging processes involved in a thermochemical energy storage cycle. [2]

Thermochemical Heat Storage

Sorption thermal storage classification [3]

Example: $MgCl_2 \cdot 6H_2O$

Fig. 4. Weight loss of $MgCl_2 \cdot 6H_2O$ versus temperature using a TGA with heating rate 2°C/min.
Example: $MgCl_2 \cdot 6H_2O$

Fig. 4. Weight loss of $MgCl_2 \cdot 6H_2O$ versus temperature using a TGA with heating rate 2°C/min.

$MgCl_2 \cdot 6H_2O \rightarrow MgCl_2 \cdot 2H_2O + 4H_2O$
**Example:** $MgCl_2 \cdot 6H_2O$

\[
MgCl_2 \cdot 6H_2O + \text{Heat} \rightarrow MgCl_2 \cdot 2H_2O + 4H_2O
\]

\[
MgCl_2 \cdot 2H_2O + 4H_2O \rightarrow MgCl_2 \cdot 6H_2O + \text{Heat}
\]

Fig. 4. Weight loss of $MgCl_2 \cdot 6H_2O$ versus temperature using a TGA with heating rate 2°C/min.

Fig. 5. An adsorption heat storage cycle. [4]

### Potential Materials for TCES

**Table 1: Details of Potential Materials**

<table>
<thead>
<tr>
<th>Materials</th>
<th>Charging Temperature</th>
<th>Storage Density (Wh/kg)</th>
<th>Supplier</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>$MgCl_2$</td>
<td>130°C</td>
<td>477</td>
<td>Fisher Scientific</td>
<td>1KG/£99.20</td>
</tr>
<tr>
<td>$MgSO_4$</td>
<td>150°C</td>
<td>442</td>
<td>Fisher Scientific</td>
<td>1KG/£106.00</td>
</tr>
<tr>
<td>$CaCl_2$</td>
<td>100°C</td>
<td>623</td>
<td>Fisher Scientific</td>
<td>1KG/£46.00</td>
</tr>
<tr>
<td>$SrCl_2$</td>
<td>100°C</td>
<td></td>
<td>Fisher Scientific</td>
<td></td>
</tr>
<tr>
<td>AIPO-18</td>
<td>95°C</td>
<td>243</td>
<td>Fisher Scientific</td>
<td></td>
</tr>
<tr>
<td>SAPO-34</td>
<td>95°C</td>
<td>203</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Limitations in mass and heat transfer

**Host Materials**

- Zeolite 13X: Fisher Scientific, 1KG/£38.08
- Silica Gel: Fisher Scientific, 1KG/£58.20
- Activated Carbon: Sigma Aldrich, 1KG/£51.10

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**Note:** The table includes materials and their suppliers, along with their respective charging temperatures and storage densities. The prices are listed per kilogram.

**Agglomeration**
Research Plan

Step 1: Materials

- Mixture Salts: \( MgCl_2 + MgSO_4/ CaCl_2/ SrCl_2 \)
- Host Materials: Zeolite 13X/Silica Gel/Activated Carbon + Salts
- Additives: Nanoparticles

Wetness Impregnation
Research Plan

Step 1: Materials

MgCl₂

Mixture Salts

Host Materials

Additives

Small Scale

Medium Scale

Thermophysical Properties

Theoretical Storage Density

Materials

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Step 2: Hydration and dehydration cycle tests in small scale (~10mg).

Cycle Tests

- Cycle Stability
- System Energy Storage Density \( W = \frac{Q_{\text{discharge}}}{\text{Volume}} \)
- Energy Storage Efficiency \( \eta = \frac{Q_{\text{discharge}}}{Q_{\text{charge}}} \)

Dehydration

(charging)

Hydration

(discharge)
Step 3: Experimental Reactor and System Design in medium scale (~50g).

- **System**: Open/Closed
- **Reactor**: Particles
  - Beads
  - Pellets
  - Honeycombs
Things To Do

- Making materials for hydration/dehydration cycle tests;
  - Lab training (TGA/DSC done);
- Conducting thermophysical analysis of materials;
- Conducting hydration/dehydration cycle tests;
- Designing rig for medium scale experiments.
Low Temperature Heat Recovery and Distribution Network Technologies

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THANK YOU!