Intelligent Hybrid Thermo-Chemical District Networks

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“Too much energy is being wasted: the amount of heat produced from industrial processes and wasted in the atmosphere or into water in the EU is estimated to be enough to cover the EU's entire heating needs in residential and tertiary buildings”

EU Heating and cooling strategy, Press release, Feb 2016
Excess heat vs. heat demand

Source: Persson et al. 2014
Excess heat temperature levels

Demand density: Accessing Low-Demand Areas

Better access to heat demand by new technology

Heat demand density in TJ/km²a vs. Heat demand in EJ/a

- Today
- Conventional DH
  - 2050 (HRE-EE)
  - 2050:40%
- Thermo-chemical
  - 2050 (HRE-EE)
  - Today: 25%

Data: Persson, Möller and Werner (2014)
Thermo-chemical district networks

Excess heat from industry

Unused renewables

Recovered (latent) heat from buildings

Thermo-chemical network

Heat demand in buildings

Air conditioning in buildings

Drying demand Process heat and cold
Absorption heat pump / chiller — Closed process

- Work medium in TC network: Water
- Absorbent: Hygroscopic salt solution
Thermo-chemical networks

Cutup of the process

=> Process at different location and time => Lossless transport and storage

Regeneration

Residual heat from regeneration (lower temperature)

Driving heat (high temperature)

Services

Environmental heat

Useful heat
Thermo-chemical technology: Absorption / Desorption

Absorption
- Humidity uptake
- Heat generation
- Dehumidification
- Cooling supply
- Heat recovery / latent energy recovery

Desorption
- Regeneration by excess heat / renewables
- Air humidification

Thermo-chemical network
### Technology benefit: Drying

#### ibd Application Case 2: Drying by desiccant from the network

<table>
<thead>
<tr>
<th>System</th>
<th>Description</th>
<th>Energy Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Desiccant Drying System</strong></td>
<td>85% Less primary energy</td>
<td><strong>0.15 kWh</strong>&lt;sub&gt;prim&lt;/sub&gt; per kg water</td>
</tr>
<tr>
<td>Hybrid District Network</td>
<td>Concentrated Desiccant C = 31%, m′ = 0.15 kg/s</td>
<td>P&lt;sub&gt;drying, tot&lt;/sub&gt; = 54 kW</td>
</tr>
<tr>
<td>Absorber</td>
<td>Dry Air ( T = 60^\circ C, RH = 45% ), ( V^\prime = 4.1 \text{ m}^3/\text{s} )</td>
<td>X&lt;sub&gt;drying&lt;/sub&gt; = 23.5 g/s</td>
</tr>
<tr>
<td></td>
<td>Humid Air ( T = 49^\circ C, RH = 95% )</td>
<td>P&lt;sub&gt;gas&lt;/sub&gt; = 13 kW</td>
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</tbody>
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<tr>
<td><strong>Conventional Drying System</strong></td>
<td></td>
<td><strong>1.06 kWh</strong>&lt;sub&gt;prim&lt;/sub&gt; per kg water</td>
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<tr>
<td>Environmental Air</td>
<td>Air ( T = 10^\circ C, RH = 50% ), ( V^\prime = 1.5 \text{ m}^3/\text{s} )</td>
<td>X&lt;sub&gt;drying&lt;/sub&gt; = 23.5 g/s</td>
</tr>
<tr>
<td></td>
<td>Air ( T = 30^\circ C, RH = 62% )</td>
<td>P&lt;sub&gt;gas&lt;/sub&gt; = 90 kW</td>
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</tbody>
</table>

P<sub>gas</sub> = 13 kW
Experiences with absorption processes

Heat recovery with open sorption processes

German Sport University, Cologne (D)

Absorber

Desorber

Condenser

Solution circuit

Solution cooler

Flue gas outlet

Heat input: e.g. flue gas, steam

Heat source: flue gas

Absorption medium: hygroscopic salt solution

Working fluid: Water of flue gas

Heating plant
Buch-Berlin (D)
H-DisNet

Laboratory demonstrator

“SMART”

Siemens DEMS control
Example
Integrated District Energy Assessment by Simulation

Modelica environment to assess PV integration in districts
Primary copper production process

Making use of residual heat
Corrosion free thermal networks

District Heating/Cooling

Indoor heating/cooling
Conclusions: Thermo-chemical district networks

- Multifunctional smart network
- Regeneration and service at different levels possible
- Low-grade heat (30 to 60 °C) → Heat cascading
- No thermal losses → Long-distance transport (> 50km) → Short and medium term storage
- Higher energy density
- Different temperature levels

Heat sources:
- Residual heat from industry
- Unused renewables (e.g. excess solar thermal in summer or wind power)
- DH return flow

Services:
- Drying
- Space heating
- Space cooling
- Air conditioning and humidity control

Heat sources:
- Residual heat from industry
- Unused renewables (e.g. excess solar thermal in summer or wind power)
- DH return flow