Large heat pumps in European district heating systems

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Heat Roadmap Europe

Heat Roadmap Europe I (2012) – quantified advantages of expanding DH to 30% and 50% of the heat demand:

- Reduction of the Primary Energy Supply by 40%
- Reduction of the CO2 emissions
- Enable the use of more renewable energy and waste heat
- Approximately 220,000 jobs to be created

Heat Roadmap Europe II (2014) – synergies between energy savings & DH to cover 50% of the total heat demand

- Cheaper comfort – 100B€ cheaper
- Faster decarbonisation – recycling waste heat
- Better energy – diverse energy supply
The availability of choices

- Real alternatives
- Promotion of clear technological alternatives
- End-of-pipe solutions ➔ Continuity approach ➔ Discontinuity approach

Photos: GE, Zoonar, GEA, reddit.com, Wikipedia.com
The role of large heat pumps

Large heat pumps as critical enablers for the integration of the heating, cooling and electricity sectors.

The share of large heat pumps in 2050 according to HRE scenario.

Market development

- 106 compressor + 6 absorption units > 1 MWth
- Total power output 1346.5 MWth representing 5.9 to 8.8 TWh/year (if operated 50-75% of the time)
- Covering 2% of the DH capacities
- More installed units starting with mid-2000
### The survey

<table>
<thead>
<tr>
<th>Country</th>
<th>Power (MWth)</th>
<th>Heat plants</th>
<th>LHP units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>84,5</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Sweden</td>
<td>1022,3</td>
<td>13</td>
<td>43</td>
</tr>
<tr>
<td>Denmark</td>
<td>45</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>Finland</td>
<td>154,6</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Italy</td>
<td>36,6</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Switzerland</td>
<td>35,4</td>
<td>9</td>
<td>13</td>
</tr>
</tbody>
</table>

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<th>Power (MWth)</th>
<th>Heat plants</th>
<th>LHP units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>10,1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Lithuania</td>
<td>15</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Slovakia</td>
<td>1,8</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>6,4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Poland</td>
<td>3,7</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>France</td>
<td>5,5</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1,2</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Heat sources

<table>
<thead>
<tr>
<th>2-9°C</th>
<th>10-20°C</th>
<th>11-40°C</th>
<th>14-46°C</th>
<th>10-40°C</th>
<th>15-74°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea water</td>
<td></td>
<td></td>
<td>Waste heat (diverse industrial processes)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lake water</td>
<td>Sewage water</td>
<td>Flue gas</td>
<td>Heat storage (solar)</td>
<td></td>
<td>Geothermal (ground source)</td>
</tr>
<tr>
<td>River water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#1 – Sewage water
#2 – Waste heat (including flue gas)
#3 – Sea, lake, river
#4 – Geo-thermal
Operating temperatures

- Dependent of the type of district heating => not standardized
  - 70 - 80°C – most common range of temperatures
  - < 70°C – low temperature systems
  - > 80°C – some of the best examples: Drammen, Milan, Helsinki, Mantsala

- Low return temperatures
- Low supply temperatures
- Less heat losses
- Less stress on components

<table>
<thead>
<tr>
<th>DH t°C</th>
<th>41-50</th>
<th>51-60</th>
<th>61-70</th>
<th>71-80</th>
<th>81-90</th>
<th>91-100</th>
</tr>
</thead>
<tbody>
<tr>
<td># LHP units</td>
<td>1</td>
<td>2</td>
<td>22</td>
<td>36</td>
<td>35</td>
<td>1</td>
</tr>
</tbody>
</table>
The average COP is 3.74
- COP 6.5 and 5.4 for 2 heat pumps in Sweden which increase the return water temperature
- COP 5.5 for heat pump in low temperature DH network
- The lowest COP belongs to the absorption heat pumps
Refrigerants

- R134a is the most popular
- Used to retrofit the heat pumps in Sweden
- Restrictions in Denmark and Switzerland
- Natural refrigerants are picking up
- NH3 the most promising
- CO2 still requires more development for high capacities
System operation

- 20 base load suppliers

- 33 secondary load suppliers – 18 working in combination with CHP

- CHP-HP combination can take advantage of the flexibility of fuels and the low prices of electricity

- Open District Heating

*Heat pump as part of CHP operation. Replication (Blarke & Lund, 2007)*
District cooling

- 22 of heat pump plants
- It is seen as an opportunity to increase the efficiency of plants (trigeneration)
- Good practice examples: Helsinki (Kari Vala), Oslo (Sandvika), Stockholm (Nimrod)
- In Sandvika, individual cooling electricity requirements would have been 10 times higher than for using DC (Friotherm)
Technology is already available to be replicated!

BECAUSE LARGE HEAT PUMPS CAN:

- Capture many types and temperatures of heat sources
- Deliver required district heating temperatures
- Take advantage of natural refrigerants
- Balance the heating, cooling and electricity grids

BUT...

- Technology faces lack of experience and know-how
- Policy makers prefer to remain “technology neutral”
- Fossil fuel subsidies do not help
- Spatial planning is usually ignorant to available heat sources
Thank you for your attention!