Technical challenges and solutions for the integration of low-grade heat sources into existing networks and buildings

Jakob Zinck Thellufsen
Assistant Professor, Aalborg University
Agenda

• Current status on district heating

• Low temperature district heating
  • Technical aspects
  • Utilisation of renewable sources

• The role of low temperature district heating in Smart Energy Aalborg
District heating in Europe

[Graph showing citizens with access to district heating networks (year 2012)]

Potential for heating in Europe

- Heat Roadmap Europe 1 and 2. Focus on 27 EU countries together.

- Stratego / Heat Roadmap Europe 3
  - Concrete plan for 5 EU countries

- Heat Roadmap Europe 4
  - Concrete plan for 14 countries in EU.

- https://heatroadmap.eu/
Steam systems (1st generation)

- High temperature
- Predominantly in systems before 1930
- High losses
- Can be used for industrial processes
High temperature water systems (2\textsuperscript{nd} generation)

- 1930-1980

- Still remains in parts of the current water based systems

- Pressurized high temperature water (>100 °C)
Medium temperature water systems (3rd generation)

- 1980-2020

- The current system in most Scandinavian systems

- Between 70-95 °C
Low temperature district heating (4\textsuperscript{th} generation)

- Utilise more of the energy
- Enable use of low temperature renewable sources

http://www.4dh.dk/
Transitioning to low temperature district heating

- Proper design of networks and consumer connections
- Right compatibility with the buildings stock
- Existing district heating systems
  - Adapting installations
  - Potential retrofitting of buildings
- New development areas and new district heating systems
  - In low energy buildings, low temperature district heating can be especially suitable
Compatibility with existing building stock

• Space heating
  • Poorly insulated buildings require more energy
  • Current equipment might not be scaled for low temperature district heating
    • Equipment changes
    • Renovation of the building stock
  • Introduce thermostatic valves to control comfort levels

• Domestic hot water
  • Low temperature can lead to legionella in the water tank
    • Plate heat exchanges can be a solution
Compatibility with existing heat network

• Lower temperature can lead to higher flow rates
  • Low supply temperature requires that the return temperature is lowered too
  • From 80-40 to 50-20, still have a higher temperature difference

• New excess heat sources can require new networks

• Boosting technology can become relevant
  • To increase temperature from a supply source
  • To increase temperature certain places in the grid in cold seasons
Integration of renewable energy

• Geothermal
  • Utilise heat either through heat pumps or directly in the network
  • Most resources are low to medium temperature

• Solar thermal
  • Seasonal by nature
  • Potential for large thermal storages
  • Requires space
4GDH’s role in Smart Energy Aalborg

• The goal is to transition Aalborg to 100% renewable energy

• Utilising the principles of smart energy systems and low temperature district heating

• Current system is 3rd generation district heating
Current system in Aalborg

- Wind: 0.24 TWh
- Solar PV: 0.01 TWh
- Solar Thermal: 0 TWh
- Excess heat: 0.34 TWh

Fossil Fuels
- Coal: 3.51 TWh
- Oil: 2.33 TWh
- Natural Gas: 0.42 TWh
- Biomass, Waste, etc.: 0.82 TWh

DH demand: 2.06 TWh
Individual Heating: 0.5 TWh

Transport: 2.15 TWh
Industry: 1.03 TWh

Electricity demand: 1.15 TWh
Export: 0.3 TWh
CHP (incl. Boilers) & Waste: 1.72 TWh
HPs & Electric heating: 0.07 TWh
Indv. heating: 0.1 TWh
Transport: 0.09 TWh
Industry: 0.77 TWh
Other: 0.26 TWh
Transitioning to renewable energy

• The transition has to be done in away that does not limit other countries, cities and municipalities to transition to renewable energy

• Limiting biomass use
• Including transport based on both local and global transportation
• Defining the industrial demand related to inhabitants
Included benefits from low temperature district heating

• Low temperature district heating is a key part of the vision

• Allows for better efficiencies in heat pumps
• Allows for lower losses in the district heating grid

• It requires investments in energy savings in the buildings
Industrial waste heat

- Low temperature district heating enables increased use of industrial waste heat
- Cement industry in Aalborg
  - Currently 20% of the heat demand
- In total a potential to increase from 1200 TJ to 3100 TJ
  - We use 2600 TJ

<table>
<thead>
<tr>
<th>Projekt</th>
<th>Investering</th>
<th>Merproduktion (lf. 2016 produktion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forbedre udnyttelse af overskudsvarme ved eksisterende anlæg</td>
<td>Ingen</td>
<td>500 TJ</td>
</tr>
<tr>
<td>Optimering af eksisterende anlæg VG1</td>
<td>Investerings ikke beregnet</td>
<td>313 TJ</td>
</tr>
<tr>
<td>Optimering af eksisterende anlæg VG2</td>
<td>Investerings ikke beregnet</td>
<td>75 TJ</td>
</tr>
<tr>
<td>Øge potentialet af overskudsvarme ved investering i ny teknologi/anlæg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Projekt 1: Varmegenvinding fra den grå ovn (grå cement)</td>
<td>DKK 48 mio.</td>
<td>350 TJ</td>
</tr>
<tr>
<td>Projekt 3: Sænkning af returtemperaturen ved installation af varmepumpe (VG1)</td>
<td>DKK 16 – 25 mio.</td>
<td>3GDH: 122 TJ</td>
</tr>
<tr>
<td>Projekt 4: Opsamling af strålevarme fra de hvide ovne med varmeskålde</td>
<td>Forsigtigt skæn: DKK 225 mio.</td>
<td>540 – 610 TJ</td>
</tr>
<tr>
<td>Projekt 5: Udnyttelse af varme fra filtratvand med varmepumpe</td>
<td>DKK 7 – 9 mio.</td>
<td>3GDH: 45 TJ</td>
</tr>
</tbody>
</table>

Tabel 2 – Nye overskudsvarme-potentialer ved Aalborg Portland [Aalborg Portland, 2018]
Heat pumps and geothermal

• Utilise 100 MW thermal capacity on heat pumps
  • Can be seawater heat pumps or geothermal

• 20 MW heat pumps running on waste heat from industry

• Utilisation of a large 40 GWh seasonal storage
The 100% renewable Smart Energy Aalborg
If no low temperature district heating

• We do not gain benefits from reduced losses and increased efficiencies
• Result of not achieving savings
If no industrial excess heat

- We might not be able to rely so much on excess heat from the cement industry
If no district heating

- If we do not have district heating, what is the consequence of changing to individual heat pumps
Summary

• It is technical possible

• It gives technical and socio economic benefits

• It requires planning