Determining the feasibility of excess heat utilization in district heating system consisting of natural gas cogeneration and solar thermal

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Introduction

• Heating and cooling sector – the most energy intensive sector in the EU

• European Commission – The first heating and cooling strategy recognized the significance of district heating and cooling

• Focus on renewable energy sources and excess heat utilization

• Significant potentials – enough excess heat to cover the demand of all residential and service buildings in Europe
Levelized cost of excess heat

- A part of heat production from the natural gas district heating is substituted by **excess heat**
- It is assumed that the temperature level of the available excess heat source is *high enough for direct utilization*
- This scenario includes calculation of the **maximum feasible distance** of the potential excess heat source, taking into account **different quantities** of the available excess heat in the area

\[
\text{LCOEH} = \frac{I_{HE} \cdot CRF \cdot (1 - TD_{pv})}{8760 \cdot i \cdot (1 - T)} + \frac{O_{HE,\text{total}}}{8760 \cdot i} + c_{\text{excess heat}} \ [€/kWh]
\]
Levelized cost of excess heat

• When calculating LCOEH, the cost for the installation of distribution network is not included in the equation

• Maximum potential distance of the heat source from the demand, i.e. the extra revenue which can be used to finance the construction of the distribution network

\[ R_{EH} = E_{total} \cdot \eta_{heat} - \left( E_{EH} \cdot LCOEH + E_{DH} \cdot LCOH \right) - \frac{l \cdot n \cdot c_{pipes}}{\text{€}} \]

• The sensitivity analysis has been made by changing the values of available excess heat, costs of pipes and the cost of excess heat

<table>
<thead>
<tr>
<th>Excess heat price [€/MWh]</th>
<th>Cost of distribution pipes [€/m]</th>
<th>Available excess heat supply [GWh]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>200</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>400</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>600</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>800</td>
<td>40</td>
</tr>
</tbody>
</table>
Levelized cost of excess heat - results

Excess heat price 1€/MWh

Excess heat price 2€/MWh

Excess heat price 3€/MWh

Excess heat price 4€/MWh
Environmental impact analysis - results

<table>
<thead>
<tr>
<th>Emissions Type</th>
<th>Current situation</th>
<th>Natural gas district heating</th>
<th>Natural gas district heating + 40 GWh excess heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx emissions (kg/a)</td>
<td>25,783.24</td>
<td>3,292.07</td>
<td>1,707.62</td>
</tr>
<tr>
<td>PM emissions (kg/a)</td>
<td>1,331,938.62</td>
<td>29.93</td>
<td>15.52</td>
</tr>
<tr>
<td>CO emissions (kg/a)</td>
<td>2,153,771.65</td>
<td>70,013.02</td>
<td>36,316.36</td>
</tr>
</tbody>
</table>
Scenarios

• Scenario 1
  20 MW\textsubscript{th} natural gas CHP
  30 MW\textsubscript{th} natural gas peak boiler
  10,000 m\textsuperscript{2} solar collectors
  1,321 MWh thermal storage

• Scenario 2
  20 MW\textsubscript{th} natural gas CHP
  30 MW\textsubscript{th} natural gas peak boiler
  10,000 m\textsuperscript{2} solar collectors
  1,321 MWh thermal storage
  40 GWh excess heat
Analysis on an hourly level
Results

Heat supply (MW)

Date

Peak load boiler
CHP
Excess heat
Solar thermal
Heat demand
Conclusions

• Needed peak load boiler capacity reduced by 3 MW
• Peak load boiler operation reduced by 29.3 %
• Production units start operation 13 days later in autumn with EH
• Solar collector production remains the same
• 17,847 MWh excess heat utilized – 44.6% of available amount
• Storage needed
Thank you for your attention!

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