Techno-economic analysis of low-temperature district heating network implementation in the city of Nottingham, UK

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Outline

- Background
- Demonstration Site
- Research Aims
- Scenarios
- Method
- Results
- Conclusion
District Heating System in Nottingham

- 4900 homes and commercial buildings
- 68 km of insulated pipework
- Heat is coming from Eastcroft Energy From Waste incineration plant
- 144,000 MWh annual heat demand
- Network supply temperature is between 85-120°C
- Network return temperature is around 70°C
District Heating intervention in Nottingham

High return temperature shows sufficient capacity for a LTDH intervention to the nearby areas rather than extending high temperature network.
District Heating intervention in Nottingham

Low-temperature network
50-60°C

Existing network
District Heating intervention in Nottingham

Background

Demo Site

Research Aims

Scenarios

Method

Results

Conclusion

Low-temperature network
50-60°C
LTDH Demonstration Site

Background  Demo Site  Research Aims  Scenarios  Method  Results  Conclusion

Byron 31 Flats
Keswick 14 flats
Haywood 29 Flats
Morley 20 Flats

3rd international conference on
SMART ENERGY SYSTEMS AND 4TH GENERATION DISTRICT HEATING
Copenhagen, 12-13 September 2017
www.4dh.eu  www.reinvestproject.eu  www.heatroadmap.eu
Buildings Retrofit

Morley Court

3rd international conference on
SMART ENERGY SYSTEMS AND 4TH GENERATION DISTRICT HEATING
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Research Aim

A techno-economic analysis of low-temperature district heating intervention incorporated with buildings retrofit to evaluate its competitiveness compared to existing heating systems in the demonstration site through studying 4 scenarios.
Scenario 1

Gas Boiler
No retrofit in flats

- Hot and cold taps
- Gas boiler
- Main water
- Radiators
Scenario 2

Gas Boiler Retrofit in flats
Scenario 3

LTDH
No retrofit in flats

Heat Interface Unit (HIU)
Substation

Hot and cold taps

Main water

Radiators

Low-temperature District Heating
Scenario 4

LTDH Retrofit in flats
Building energy performance

Simulation of hourly heat demand profile

- Weather data: Nottingham 2016
- Peak heat load and hourly space heating demand profile: Design Builder Simulation Software

<table>
<thead>
<tr>
<th>Peak load</th>
<th>Before Retrofit [kW/Flat]</th>
<th>After Retrofit [kW/Flat]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Byron Court</td>
<td>5.18</td>
<td>3.24</td>
</tr>
<tr>
<td>Keswick Court</td>
<td>5.35</td>
<td>3.30</td>
</tr>
<tr>
<td>Haywood Court</td>
<td>5.04</td>
<td>3.21</td>
</tr>
<tr>
<td>Morley Court</td>
<td>5.35</td>
<td>3.30</td>
</tr>
</tbody>
</table>

- Domestic hot water demand is modelled applying the BRE (Building Research Establishment) domestic energy model
District Heating Network Hydraulic Design

Network layout (including both branch pipes and service pipes to the properties)

<table>
<thead>
<tr>
<th>Component</th>
<th>Length [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service pipes</td>
<td>878</td>
</tr>
<tr>
<td>Branch Pipes</td>
<td>244.5</td>
</tr>
</tbody>
</table>
# District Heating Network Hydraulic Design

## Network design criteria:
- The design supply temperature: 60°C
- The design return temperature: 30°C
- Max flow velocity: 2 m/s
- Max pressure drop: 8 bar
- Optimal maximum allowed pressure drop (for the longest route in the network)
- Simultaneity factor is applied for both SH and DHW demand

<table>
<thead>
<tr>
<th>Pipe dimension range</th>
<th>Before Retrofit</th>
<th>After Retrofit</th>
</tr>
</thead>
<tbody>
<tr>
<td>DN75-DN20</td>
<td>DN63-DN20</td>
<td></td>
</tr>
</tbody>
</table>
District Heating Network Simulation

LTDH network one year operation is simulated in a thermal-dynamic modelling tool[*] based in hourly time interval.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of connected Consumers</td>
<td>94</td>
</tr>
<tr>
<td>Pipe types</td>
<td>PEXFlexta series 2</td>
</tr>
<tr>
<td>Pipe network length</td>
<td>1122 m</td>
</tr>
<tr>
<td>Number of bypasses</td>
<td>8</td>
</tr>
<tr>
<td>Bypass set point temperature</td>
<td>50 [°C]</td>
</tr>
<tr>
<td>Supply Temperature to the network</td>
<td>60 [°C]</td>
</tr>
<tr>
<td>Return temperature from consumers</td>
<td>30 [°C]</td>
</tr>
<tr>
<td>Soil temperature</td>
<td>8 [°C]</td>
</tr>
</tbody>
</table>

* A thermal-dynamic modelling tool developed in Matlab programming language.
# Results

LTDH implementation for non retrofitted and retrofitted buildings

<table>
<thead>
<tr>
<th>Energy Performance</th>
<th>Before Retrofit</th>
<th>After Retrofit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Annual heat loss</td>
<td>[MWh]</td>
<td>87.90</td>
</tr>
<tr>
<td>Total annual consumers heat demand</td>
<td>[MWh]</td>
<td>1372.01</td>
</tr>
<tr>
<td>Total annual heat production</td>
<td>[MWh]</td>
<td>1460.68</td>
</tr>
<tr>
<td>Share of heat loss</td>
<td>[%]</td>
<td>6.02</td>
</tr>
</tbody>
</table>

www.4dh.eu        www.reinvestproject.eu        www.heatroadmap.eu
## Results

LTDH implementation for non retrofitted and retrofitted buildings

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<th>Energy Performance</th>
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<th>After Retrofit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Annual heat loss</td>
<td>87.90 [MWh]</td>
<td>86.14 [MWh]</td>
</tr>
<tr>
<td>Total annual consumers heat demand</td>
<td>1372.01 [MWh]</td>
<td>810.76 [MWh]</td>
</tr>
<tr>
<td>Total annual heat production</td>
<td>1460.68 [MWh]</td>
<td>897.81 [MWh]</td>
</tr>
<tr>
<td>Share of heat loss</td>
<td>6.02 [%]</td>
<td>9.59 [%]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Economic</th>
<th>Before Retrofit</th>
<th>After Retrofit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrofit cost</td>
<td>0 [M€]</td>
<td>0.386 [M€]</td>
</tr>
<tr>
<td>Pipe network installation cost</td>
<td>0.967 [M€]</td>
<td>0.954 [M€]</td>
</tr>
<tr>
<td>The network annual operating cost</td>
<td>0.111 [M€/year]</td>
<td>0.076 [M€/year]</td>
</tr>
</tbody>
</table>

*The DH price is 61.9 [€/MWh]*

Including annual heat cost and network annual maintenance cost
Results

Economic analysis of the four defined scenarios from the consumers perspective

The DH price is 61.9 [€/MWh] and gas price is 53.3 [€/MWh]

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Gas Boiler No retrofit</th>
<th>Gas boiler Retrofitted</th>
<th>LTDH No retrofit</th>
<th>LTDH Retrofitted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas boiler capital cost</td>
<td>[€] 255434</td>
<td>255434</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>HIU Capital cost &amp; meters</td>
<td>[€] 0.00</td>
<td>0.00</td>
<td>143043</td>
<td>143043</td>
</tr>
<tr>
<td>Heat consumption</td>
<td>[€/year] 83993</td>
<td>49634</td>
<td>88882</td>
<td>54054</td>
</tr>
<tr>
<td>Maintenance cost</td>
<td>[€/year] 15326</td>
<td>15326</td>
<td>10217</td>
<td>10217</td>
</tr>
<tr>
<td>Standing Charge</td>
<td>[€/year] 8965</td>
<td>8965</td>
<td>10778</td>
<td>10778</td>
</tr>
<tr>
<td>Life Cycle Cost</td>
<td>[M€] 2.66</td>
<td>1.98</td>
<td>2.46</td>
<td>1.77</td>
</tr>
<tr>
<td>Life Cycle Cost + Retrofit cost</td>
<td>[M€] 2.66</td>
<td>2.36</td>
<td>2.46</td>
<td>2.16</td>
</tr>
</tbody>
</table>

Life cycle cost analysis: 30 years life cycle Interest rate = 3% Inflation rate = 6%
Results

Consumers' Life Cycle Cost Analysis including the retrofit cost

LCC [Euro]

- Gas boiler
- HIU
- Heat
- Maintenance
- Standing charge
- Retrofit
Conclusion

- Low temperature district heating together with implementing some retrofit measures in the building is the best scenario from economic perspective.
- It is vital to include all the associated costs when evaluating the district heating interventions against its rivals.
- There are different district heating schemes in UK with different prices varies between 43-163 [€/MWh], therefore the feasibility of this kind of intervention needs to be studied for different schemes.

Next Steps

- Looking into the cost of the DH production from the heat providers point of view
- Research the replication of this intervention for other areas in Nottingham
Thank You

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