Hypothetical heating grid modelling with graph theory. A decision support tool for planning.

Ivan Dochev, Hannes Seller, Irene Peters
Technical Urban Infrastructure Systems Group, HafenCity University Hamburg
Georg K. Schuchardt
Fernwärme Forschungsinstitut Hannover

3RD INTERNATIONAL CONFERENCE ON
SMART ENERGY SYSTEMS AND
4TH GENERATION DISTRICT HEATING
COPENHAGEN, 12–13 SEPTEMBER 2017
GEWISS Project Hamburg

GIS to support the energy planning by bringing together heat demand, waste heat potential, heating grids and urban development aspects (urban densification, new developments, building renovations) with the possibility to model future scenarios.
GEWISS Project
Linear Heat Density
(Wärmebelegungsdichte)

\[ LHD = \frac{Q_a}{l} \]

where:

- \( Q_a \) = Total heat demand of all heat users in MWh/a
- \( l \) = Total length of heating grid in meters, supply and return pipes counted as one.
Linear Heat Density at scale?

3rd international conference on SMART ENERGY SYSTEMS AND 4TH GENERATION DISTRICT HEATING Copenhagen, 12-13 September 2017
Types of grid layout

Source: (Fraunhofer Institut für Umwelt-, Sicherheits- und Energietechnik UMSICHT, 1998, p. 37)
Hypothetical grid geometry generation

Making use of Graph Theory – A python numpy implementation of a Minimum Spanning Tree algorithm (Prim’s Algorithm). Weights applied to give preference to standard connections.
Example of hypothetical grids
Plausibility

Comparison with two real heating grids (built and operational)

<table>
<thead>
<tr>
<th>Real length</th>
<th>Hypothetical length</th>
<th>% Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>1061</td>
<td>951</td>
<td>10%</td>
</tr>
<tr>
<td>1493</td>
<td>1280</td>
<td>14%</td>
</tr>
</tbody>
</table>

real

hypothetical

3rd international conference on SMART ENERGY SYSTEMS AND 4TH GENERATION DISTRICT HEATING Copenhagen, 12-13 September 2017
Plausibility

Comparison with two real heating grids (built and operational)

<table>
<thead>
<tr>
<th>Real length</th>
<th>Hypothetical length</th>
<th>% Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>1061</td>
<td>951</td>
<td>10%</td>
</tr>
<tr>
<td>1493</td>
<td>1280</td>
<td>14%</td>
</tr>
</tbody>
</table>

real

hypothesis

3rd international conference on SMART ENERGY SYSTEMS AND 4TH GENERATION DISTRICT HEATING Copenhagen, 12-13 September 2017
Linear Heat Density Analysis - Spatial Pattern

0-0.5 MWh/m*a

0.5-1.5 MWh/m*a

1.5-2 MWh/m*a

>2 MWh/m*a

3rd international conference on SMART ENERGY SYSTEMS AND 4TH GENERATION DISTRICT HEATING Copenhagen, 12-13 September 2017
Application – decision support (2)
Application – decision support (2)
Thank you for the attention