District Heating and Cooling with District (hybrid) shallow geothermal Systems

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Thermal ‘battery’
(the ground!)
Geothermal – Thermal storage (to optimise)

Thermal ‘distributor’
(the ground!)
Thermal ‘battery’
(the ground!)

Thermal ‘distributor’
(the ground!)
District hybrid geothermal systems


Peak thermal power:

$$HD_{max} = 83 \ kW$$

Shave factor: $$\alpha = 0.6$$

(greater $$\alpha$$ – more geothermal)

Maximum geothermal power:

$$HD_{geo} = 50 \ kW$$

- The capital cost is significantly reduced
- ~ 90% of energy still comes from the GSHP system
Individual and district hybrid geothermal systems

Individual vs. District HGSHP systems:

- Annual building heating demands are the same
- Installed capacity & capital costs are the same
- The district system can supply more geothermal energy
Can district hybrid geothermal systems be more economical than individual hybrid geothermal systems of the same buildings?
## Case study: Financial assumptions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation cost of 1 kW of GSHPs, $i_{c_{GSHP}}$, £</td>
<td>240</td>
</tr>
<tr>
<td>Installation cost of 1 kW of gas boiler, $i_{c_{boil}}$, £</td>
<td>25</td>
</tr>
<tr>
<td>Installation cost of 1 m of GHEs, $i_{c_{GHE}}$, £</td>
<td>37.5</td>
</tr>
<tr>
<td>1 kWh from electricity, $c_e$, £</td>
<td>0.17</td>
</tr>
<tr>
<td>1 kWh from gas, $c_g$, £</td>
<td>0.05</td>
</tr>
<tr>
<td>COP of GSHPs, $COP_{GSHP}$</td>
<td>3.5</td>
</tr>
<tr>
<td>COP of gas boiler, $COP_{boil}$</td>
<td>0.95</td>
</tr>
<tr>
<td>Life time of HGSHP system, $T_{life}$, years</td>
<td>20</td>
</tr>
<tr>
<td>Discount rate, $DR$</td>
<td>0.05</td>
</tr>
<tr>
<td>Government incentive rate per 1 kWh of geothermal heat, $r_{RHI}$, £</td>
<td>0.0884</td>
</tr>
</tbody>
</table>
1. Individual and district HGSHP were sized for different shave factors $\alpha = (0, 1)$.

2. For each $\alpha$, the annual energy provided by a GSHP and a gas boiler was calculated for individual and district HGSHP systems.

3. For each $\alpha$, TNC and PBP were calculated for individual and district HGSHP systems.
Results: “Office + Office”

- **α = 33%**
  - Gas only: 25.5 £/MWh
  - GSHP only: 23.1 £/MWh

- **α = 31%**
  - Gas only

**Mikhaylova et al 2016**

![Graph showing the total normalised cost of heating TNC, £/MWh, against capital cost C<sub>cap</sub>, £. The graph includes data points for Individual and District heating systems. The x-axis represents capital cost in £, ranging from 0 to 40,000, and the y-axis represents total normalised cost in £/MWh, ranging from 0 to 50. Two lines are shown: one for Individual heating and one for District heating. There are two boxes on the right side of the graph, one for Office heating showing 0.9 and 0.1, another for the same showing 6 am – 6 pm and 6 pm – 6 am respectively.](image-url)
Results: “Residential + Office”

Mikhaylova et al 2016
Results: Payback periods

<table>
<thead>
<tr>
<th>Payback period PBP, years</th>
<th>&quot;Office+Office&quot;</th>
<th>&quot;Residential+Office&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
<td>10.8</td>
<td>7.6</td>
</tr>
<tr>
<td>District</td>
<td>9.3</td>
<td>5.4</td>
</tr>
</tbody>
</table>