Lessons from borehole and energy pile GSHP systems in the UK
IEA HPT Annex 52

Long-term performance of GSHP systems for commercial, institutional and multi-family buildings

Final Webinar on June 13th 2022
Contents

• The Crystal Building
  – A hybrid pile/borehole system
  – Demand, SPF, Pile temperatures
  – Control systems/operation modes

• The Hugh Aston Building
  – Borehole heat exchanger systems
  – SPF, Fluid and ground temperatures
  – Heat pump cycling

• Conclusions
## Case Study: The Crystal - London

<table>
<thead>
<tr>
<th></th>
<th>The Crystal– London</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year (building)/GSHP</td>
<td>(2012)]/2012</td>
</tr>
<tr>
<td>Net floor area</td>
<td>6,920 m²</td>
</tr>
<tr>
<td>Heating load</td>
<td>307.2 MWh/a (44.39 kWh/m²a)</td>
</tr>
<tr>
<td>Cooling load</td>
<td>172.65 MWh/a (24.95 kWh/m²a)</td>
</tr>
</tbody>
</table>
System Details – The Crystal

- **# of Boreholes**: 36
- **BH Length**: 150
- **Overall BH Length**: 5400 m
- **# of Piles**: 160
- **Pile Length**: 21 m
- **Overall Pile Length**: 3360 m
- **System type**: Central HP
- **Heat pump**: X2 Water-to-Water HPs
- **Nominal capacity**: 2 x 407 kW_h / 2 x 314 kW_c
• Piles in shallow gravels and clay strata
• Boreholes into mixed lithologies and major regional aquifer
• Effective conductivity over 150m = 2.0 W/mK
Simplified schematic – The Crystal

Pictograms by TU Braunschwieig IGS, used with permission within the course of IEA HPT Annex 52
Thermal Demand

- Predicted: Heating 307 MWh/yr; Cooling 173 MWh/yr
Overall Seasonal Performance Factors
Monthly ground source heat extraction and injection
Pile Temperature – Circumferential
# Case Study: Hugh Aston Building – De Montfort University

<table>
<thead>
<tr>
<th>Hugh Aston – Leicester</th>
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</thead>
<tbody>
<tr>
<td><strong>Year (building)/GSHP</strong></td>
</tr>
<tr>
<td><strong>Net floor area</strong></td>
</tr>
<tr>
<td><strong>Monitoring Period</strong></td>
</tr>
</tbody>
</table>
System Details – Hugh Aston

<table>
<thead>
<tr>
<th># of Boreholes</th>
<th>56</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH Length</td>
<td>100</td>
</tr>
<tr>
<td>Overall BH Length</td>
<td>5600 m</td>
</tr>
<tr>
<td>Geology</td>
<td>Marl (3.2 W/mK)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>System type</th>
<th>Centralised HPs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat pump</td>
<td>X4 Water-to-Water HPs</td>
</tr>
<tr>
<td>Nominal capacity</td>
<td>4 x 110 kW\textsubscript{h} / 4 x 120 kW\textsubscript{c}</td>
</tr>
</tbody>
</table>
Simplified schematic – Hugh Aston

Pictograms by TU Braunschweig IGS, used with permission within the course of IEA HPT Annex 52
Overall Seasonal Performance Factors

<table>
<thead>
<tr>
<th>Period</th>
<th>SPF 1</th>
<th>SPF 2</th>
<th>SPF 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 2010 - Apr 2011</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May 2011 - Apr 2012</td>
<td>3.5</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>Lifetime (Feb 2010 - July 2012)</td>
<td>3.5</td>
<td>3</td>
<td>2.5</td>
</tr>
</tbody>
</table>
Borehole & Fluid Temperatures – Daily Mean
Monthly ground source heat extraction and injection
Heat Pump Cycling

Percentage difference between simulated and experimental load heat transfer

Cycle Time (Minutes)

\[ y = 0.2878e^{-0.046x} \]

\[ R^2 = 0.5662 \]
Conclusions

• Both case studies:-
  – have favourable ground temperatures, but some increase with time
  – ground loop appears over designed
  – building loads different to design (in different directions)

• Control strategy / operation mode at the Crystal appears to be effecting performance:-
  – using boreholes and piles differently
  – changed in 2018 to use more cooling mode

• Heat pump cycling at the Hugh Aston Building:-
  – Explains variation in SPF
  – Short cycles correspond to low performance
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• Hugh Aston Building
  – Dr Selvaraj Naiker
  – De Montfort University, GI Energy, N G Bailey