Building performance evaluation of dwellings
A case study of the Seager Distillery development

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Overview

– Introduction
– The site and sample dwelling
– Study scope & findings
  – Fabric performance
  – Ventilation
  – Thermal comfort
  – Energy use and benchmarking
  – Communal heating system
– Focus topic – communal heating system
– Concluding remarks
Introduction

- Part of the building performance evaluation programme funded by the Technology Strategy Board (TSB) or more recently known as Innovate UK

- 2 year study commencing post-handover to early period occupancy

- Compares the actual performance against the design intent of the apartments and communal heating system

- Highlights the reasons for any performance gaps, which provide useful learning to both Galliard Homes and the wider building industry
The site

- Seager Distillery
- Regeneration project by Galliard Homes
- Former 19th century distillery
- Deptford Bridge in Lewisham, London
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The site
The site
The site – sample dwelling
The site – sample dwelling

Three types of apartments:
- One bed
- Two bed dual aspect
- One bed duplex

Features in each unit:
- Highly-glazed
- High performance fabric
- MVHR system (no summer by-pass)
- Openable windows for additional ventilation
- Communal heating system for space heating and DHW
Study scope

The study focused on 3 apartments (one of each three types) for detailed analysis and covered all other units at high level.

<table>
<thead>
<tr>
<th>Flat Number</th>
<th>Internal Floor Area</th>
<th>Number of Bedrooms</th>
<th>Aspect</th>
<th>Floor of Apartment Block</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat 1</td>
<td>45m²</td>
<td>1</td>
<td>west facing</td>
<td>4th floor</td>
</tr>
<tr>
<td>Flat 2</td>
<td>74m²</td>
<td>2</td>
<td>west and east facing (dual aspect)</td>
<td>4th floor</td>
</tr>
<tr>
<td>Flat 3</td>
<td>63m²</td>
<td>1</td>
<td>east facing</td>
<td>4th and 5th floor (duplex flat)</td>
</tr>
</tbody>
</table>

The study covered the following aspects of the dwelling:

- Fabric performance - air tightness and insulation standards
- Performance of the ventilation system (MVHR)
- Thermal comfort, i.e. issues of overheating
- Energy use and performance against benchmark
- Performance of the communal heating system
Fabric performance - air tightness

The graph illustrates the air permeability at 50Pa for different flats.

- Flat 1: Design air permeability (SAP) is around 8 m³/h.m², with initial test results at 3 m³/h.m², and repeat test results at 2 m³/h.m².
- Flat 2: Design air permeability (SAP) is around 8 m³/h.m², with initial test results at 4 m³/h.m², and repeat test results at 3 m³/h.m².
- Flat 3: Design air permeability (SAP) is around 8 m³/h.m², with initial test results at 5 m³/h.m², and repeat test results at 4 m³/h.m².

The on completion (original testing contractor) results are shown in red, with Flat 1 having a value slightly above 8 m³/h.m², Flat 2 around 8 m³/h.m², and Flat 3 above 8 m³/h.m².
Fabric performance - insulation

- Limited in-situ U-value by 3rd party suggested external fabric performance close to as-designed

- Thermographic imaging also revealed some incidences of cold-bridging, which could be improved

<table>
<thead>
<tr>
<th>External wall</th>
<th>Actual</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-value (W/m²K)</td>
<td>0.23</td>
<td>0.25</td>
</tr>
</tbody>
</table>
Ventilation: MVHR

- The MVHR ventilation rate (supply and extract) were measured for the 3 apartments.
- 2 apartments measured demonstrated much lower measured ventilation than reported during commissioning both for supply and extract.
- Rates are below BRegs Part F 2006 recommendation at normal operation.
- Could lead to excessive moisture build-up, condensation and mould growth causing health issues.
Ventilation: MVHR

Further inspection also revealed:

- Dirty extract filter in one inspected MVHR unit suggests schedule of installation, commissioning and frequency of maintenance could be improved.
- Clogged up external inlet grille suggests more frequent cleaning and easier accessibility should be considered.
- Measured MVHR fan power higher than manufacturer claim of 0.59W/l/s.
Thermal comfort: overheating

The following drivers of overheating affecting thermal comfort of occupants have been identified:

• Significant distribution losses from the communal heating pipe
• Low MVHR ventilation rates
• Insufficient external shading
• High glazing proportion
• Possible reluctance of occupant opening windows to noisy exterior

Automatic vents retrofitted to smoke shaft for purge ventilation in corridors of the residential tower building
Energy use and benchmarking

Measured heat and electricity use between March 2013 and June 2014 were compared against SAP:

- Lower heating demand due to high performance fabric and heat gain from solar and distribution losses from communal heating pipes
- Higher fan energy due to lower MVHR fan efficiency although tempered by lower flow rates
- Generally, lighting energy was lower due to preference for standalone lighting (small power)
- No strong link to good daylighting
Communal heating system

- GAS BOILER 1000kW
- GAS BOILER 1500kW
- DIVERTING VALVE
- THERMAL STORE 18m³
- CHP UNIT 100kWe 165kWt
- BIOMASS BOILER 800kW
- ELECTRICITY OUTPUT

FLOW TO THE BLOCKS VIA BLOCK PLANT ROOM HEAT EXCHANGERS AND SECONDARY PUMPED CIRCUITS

April 10, 2015
Communal heating system

<table>
<thead>
<tr>
<th>Period</th>
<th>efficiency</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>O</td>
<td>N</td>
<td>D</td>
</tr>
<tr>
<td>Winter</td>
<td>32%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>19%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual</td>
<td>26%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter</td>
<td>34%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From the billing results for 2014 with 2,700 MWh consumed at the gas meter and 1,135 MWh metered at the dwellings the efficiency has increased slightly to 42%

The mean energy consumption per dwelling was 6,602kWh per annum
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Communal heating system

### Standard

**Insulation Thickness Tables to Control Heat Loss**

Based on Non-Domestic Building Services Compliance Guide:

<table>
<thead>
<tr>
<th>Steel Pipe Size</th>
<th>Water at 60°C</th>
<th>Kooltherm® max. heat loss</th>
<th>Water at 75°C</th>
<th>Kooltherm® max. heat loss</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>η=0.05 silver</td>
<td>η=0.9 black</td>
<td>η=0.05 silver</td>
<td>η=0.9 black</td>
</tr>
<tr>
<td>NB (in)</td>
<td>(mm)</td>
<td>OD (mm)</td>
<td>Kooltherm® max. heat loss (W/m)</td>
<td>Kooltherm® max. heat loss (W/m)</td>
</tr>
<tr>
<td>3/4</td>
<td>10</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>1/2</td>
<td>15</td>
<td>21.3</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>3/4</td>
<td>20</td>
<td>26.9</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>1</td>
<td>25</td>
<td>33.7</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>1 1/4</td>
<td>32</td>
<td>42.4</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>1 1/2</td>
<td>40</td>
<td>48.3</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>60.3</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>2 1/2</td>
<td>65</td>
<td>76.1</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>1</td>
<td>250</td>
<td>273.0</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

Estimated mean temperature of insulation:
- Ambient air temperature: +50°C
- Surface emittance (outer surface): 0.05
- Assumed thermal conductivity (k-value) of Kooltherm® 3.7kg/m³ insulation: 0.025 W/m·K

### Enhanced

**Insulation Thickness Tables to Control Heat Loss**

Based on nes Y50 specification.

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<tr>
<td>NB (in)</td>
<td>(mm)</td>
<td>OD (mm)</td>
<td>Kooltherm® max. heat loss (W/m)</td>
<td>Kooltherm® max. heat loss (W/m)</td>
</tr>
<tr>
<td>3/4</td>
<td>10</td>
<td>17.2</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>1/2</td>
<td>15</td>
<td>21.3</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>3/4</td>
<td>20</td>
<td>26.9</td>
<td>15</td>
<td>20</td>
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<td>20</td>
<td>20</td>
</tr>
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<td>1 1/4</td>
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<td>42.4</td>
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<td>20</td>
</tr>
<tr>
<td>1 1/2</td>
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<td>48.3</td>
<td>25</td>
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<td>40</td>
</tr>
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<td>2</td>
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<td>273.0</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>10</td>
<td>250</td>
<td>273.0</td>
<td>45</td>
<td>50</td>
</tr>
</tbody>
</table>

Estimated mean temperature of insulation:
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Communal heating system

Calculation tool that was used to calculate W/m loss for the standard conditions used for BS5422

This was used to give W/m values for the various EN253 thicknesses for direct comparison purposes
## Communal heating system

### NORFOLK HOUSE

### OPTIONS ON INCREASING INSULATION LEVELS FROM EXISTING INSULATION STANDARDS

<table>
<thead>
<tr>
<th></th>
<th>NETWORK LOSS kWh/Annum</th>
<th>% kWh REDUCTION IN HEAT LOSS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calculated using Wm-1 various Standards</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PART L 2006</td>
<td>144416</td>
<td>0</td>
</tr>
<tr>
<td>ECA &amp; Y50 ENHANCED</td>
<td>130174</td>
<td>10 %</td>
</tr>
<tr>
<td>EN253 SERIES 1</td>
<td>120256</td>
<td>17 %</td>
</tr>
<tr>
<td>EN253 SERIES 2</td>
<td>105171</td>
<td>27 %</td>
</tr>
<tr>
<td>EN253 SERIES 3</td>
<td>89492</td>
<td>38 %</td>
</tr>
</tbody>
</table>
Communal heating system

<table>
<thead>
<tr>
<th>FLOW/ RETURN °C</th>
<th>M.W.T</th>
<th>W/m</th>
<th>% REDUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 °C / 70 °C</td>
<td>75 °C</td>
<td>7.5</td>
<td>----</td>
</tr>
<tr>
<td>80 °C / 50 °C</td>
<td>65 °C</td>
<td>6.2</td>
<td>-17%</td>
</tr>
<tr>
<td>80 °C / 30 °C</td>
<td>55 °C</td>
<td>5</td>
<td>-33%</td>
</tr>
</tbody>
</table>

Above is based on EN253 Series 3 25mm dia pipe with 30mm thick phenolic insulation
### Communal heating system

<table>
<thead>
<tr>
<th>SUMMER HEAT INPUTS TO OVER-HEATING CORRIDORS WITH GLAZING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HEAT INPUT</strong></td>
</tr>
<tr>
<td>PIPE LOSS</td>
</tr>
<tr>
<td>SOLAR GAIN</td>
</tr>
<tr>
<td>LIGHTS</td>
</tr>
</tbody>
</table>

38% PIPE LOSS REDUCTION = -19% ON OVERALL GAINS TO THE SPACE (GLAZED CORRIDOR)

38% PIPE LOSS REDUCTION = -30% ON OVERALL GAINS TO THE SPACE (CORRIDOR NO GLAZING)

Therefore there is much more impact with reducing pipe losses in a corridor with no glazing.
Lessons learned

For the occupants of the dwellings

Experience in use

• Issues with use of the heating system
• Residents do not understand that the HIU (Heat Interface unit) is not a boiler
• Residents switch off the power to the HIU which is supplying the controls
• kWh heat charges give no easy price comparison for users
• Manufacturers manuals are technical so there is a need for a ‘quick user guide’ approach to user information
• Use of the MVHR supply and extract system was found to need more explanation in when the filters will need to be changed
• The boost facility on the MVHR seemed to be misunderstood and better details will be provided in future as to when it should be used.
Lessons learned

For the Community Heating System Design and Operation

• The study has led to conclusion that different design principles should be adopted depending on the size of the scheme
• E.g. A scheme for 200 to 300 apartments should have no distribution network heat exchangers. This brings lower return temperatures straight back to the condensing gas boilers
• In most of the heat schemes that have been designed for Galliard Homes as a Client, the system and central plant have been over-sized. In one case by a factor of +100%
• The lack of detailed control philosophy documentation from some Consultants has caused many problems in programming the central boiler systems.
• GH have had many experiences where the Manufacturers own representatives have not commissioned or serviced biomass boilers, CHPs etc, inline their own documentation.
Lessons learned

For the Communal Heating System Design and Operation

- Adding a heat distribution network to any system adds a large heat loss and lowers the efficiency of the scheme.
- The carbon intensity of this scheme is 0.46 kgCO2/kWh. (When only gas primary fuel is used) Thus the early gas-only communal heating schemes we were forced to use achieved no carbon emission reductions.
- The above affects the cost to residents and the cost of the losses is higher if biomass is used as a primary fuel.
- Plans to adopt higher insulation standards selectively in new systems to limit heat loss as appropriate in each section of the distribution.
- Specification of flow and return temperatures as 70/40°C. This will raise the efficiency of the central boilers and significantly reduce the losses and thus potential over-heating of corridors.
- Plans to use both lower system temperatures and higher insulation standards to avoid the use of corridor cooling ventilation systems.
Concluding remarks

• Overall, the heat consumed by the three apartments is 40 to 65% less than SAP predictions.

• Actual U-values are shown to be in line with design expectations.

• The developer achieved significantly better air permeability than assumed at design stage and included in as-built SAP.

• The actual ventilation rates were significantly less than recommended by BReg Part F for 2 apartments.

• The relatively low efficiency of the communal heating scheme is likely partly due to distribution losses within the apartment block.

• Communal heating pipe distribution losses could be a result of insufficient pipework installation quality and/or the standards of insulation on heating pipework.

• The electricity use for fixed building services within the three apartments is more variable in comparison with SAP.
Thank You

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