Case Study
GRAHAM New Head Office

Innovate UK BPE Study
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ASPIRATIONS AND INSPIRATIONS

Behind the global drive towards sustainability is the realization that we cannot continue to develop and grow without considering the broader implications of our actions. The new flagship GRAHAM HQ will demonstrate our commitment to all areas of sustainability and show that we practice what we preach.
New Flagship Head Office 2010, Hillsborough

Graham set the brief with the following core aims and objectives: -

• To provide a comfortable and inspiring work environment for staff
• To make the building as sustainable as possible.
• To make it affordable
• To be able to use it as a ‘good practice’ demonstration case study
RESPONSE TO THE BRIEF – COMFORTABLE AND INSPIRING

- Central Atrium with meeting areas
- Natural Lighting and Ventilation
- Glass lift in the centre of the building
- High quality finishes
- Spacious

- On site canteen
- Break out spaces
- Ample on site car parking
- Cycle racks, showers and lockers for cyclists
- High quality landscaping
RESPONSE TO THE BRIEF - SUSTAINABILITY

EPC
  • A rated – 18

BREEAM
  • ‘Excellent’ 79.13%

PASSIVE
  • Natural ventilation and daylighting strategies
  • Orientation to reduce heat demand in winter and heat gains in summer

DYNAMIC
  • Substitute energy demand with low carbon emission technologies
  • Innovative products
BUILDING DESIGN FEATURES

- Biomass Boiler and Oil Boiler
- Presence Detection Lighting
- High frequency energy efficient light fittings (T5 fluorescents, CFLs, LEDs)
- Automatic louvres for natural ventilation, comfort cooling and air quality
- BMS system to control ventilation and heating for 24 individual zones
- 50 individual sub-meters to monitor energy and water consumption
- Central atrium with automated controls to create passive stack ventilation
- Concrete pillars and exposed concrete ceilings for increased thermal mass
AWARD WINNING DESIGN AND CONSTRUCTION

- Sustainable Ireland Most Sustainable Building 2009
- Action Renewables Most Sustainable Building 2010
- Sustainable Ireland Most Sustainable Building 2010
- RICS Royal Institute of Chartered Surveyors Grand Final 2011
- British Council for Offices National Sustainability Award 2011
AWARD WINNING DESIGN AND CONSTRUCTION

But how does the building really perform?
GRAHAM successfully secure Innovate UK BPE Funding
Only 1 of 3 projects in Northern Ireland

2 Year Project
- University of Ulster
- Caldwell Consulting
- Graham FM & Construction
- Energy Consultants

Activities included:
- U value measurements
- Air Tightness Testing
- Thermal Imaging
- Daylight Study
- Energy Data Analysis
- TM22 CIBSE Benchmarking
- Building User Surveys
- Energy Walkrounds and Occupant Interviews
- In Situ Thermal Mannequin (UUJ)

Additional Investment has enabled installation of:
- New Energy Management Software
- Upgrades to Metering System
- Improved Energy Management Processes
  - Will enable benchmarking with other UK Office Buildings
  - Results published via TSB and Carbon Buzz website
  - Dissemination Activities
## Building Fabric Testing - U-values

<table>
<thead>
<tr>
<th>Element</th>
<th>As designed U-value</th>
<th>Building Regulations Max</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>External North Wall</td>
<td>0.29</td>
<td>0.7 (0.35 Average)</td>
<td>0.295</td>
</tr>
<tr>
<td>Glazing Curtain Walling</td>
<td>1.98</td>
<td>2.2</td>
<td>1.12</td>
</tr>
<tr>
<td>Roof</td>
<td>0.11</td>
<td>0.35</td>
<td>0.34</td>
</tr>
</tbody>
</table>
• Some thermal bridging between floors but not excessive
• Some heat loss recorded in north west corner 3rd floor
• Heat loss through vents at rear of building
• Heat loss at front entrance doors
DAILY LIGHT LEVELS

- Daylight measurements undertaken by Caldwell Consulting (and Easlar)
- In BREEAM 2006 Hea 1 daylight factor of 2% or above is considered good with above 5% excellent
- Uniformity of 0.4 or a minimum of 0.8% is considered good
- Building Achieved Average Daylight Factor above 2% throughout
- Uniformity and minimum standards also achieved
AIR TIGHTNESS AND SMOKE TESTING

Air/Smoke Test Clip
Air Tightness Levels - Similar to Building Handover 4.7 m3.h-1.m-2 @ 50 Pa
BUILDING USER SURVEY

- Feedback needed from building users on their view of whether expectations were met, and how well the building works for them. Building aims to have low resource consumption whilst still scoring highly for user satisfaction.
- All projects to use a structured survey
- Building Use Studies (BUS) Methodology
  - Questionnaire based
  - Answers processed by software
  - Produces benchmarked statistics
  - Records comments and anecdotes
BUS RESULTS SUMMARY

Summary of BUS headings. All green boxes which indicates high levels of satisfaction overall.

GRAHAM overall performance in top 5% of BPE projects.
<table>
<thead>
<tr>
<th>Green Squares</th>
<th>Amber Circles</th>
<th>Red Diamonds</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Issues scoring better than the benchmark and scale midpoint</strong></td>
<td><strong>Issues scoring between the benchmark and the scale midpoint</strong></td>
<td><strong>Issues scoring poorer than benchmark and scale midpoint</strong></td>
</tr>
<tr>
<td>Air in summer: odourless/smelly</td>
<td>Air in summer: dry/humid</td>
<td>Air in winter: still/draughty</td>
</tr>
<tr>
<td>Air in summer: overall</td>
<td>Air in summer: fresh/stuffy</td>
<td>Control over heating</td>
</tr>
<tr>
<td>Air in winter: fresh/stuffy</td>
<td>Air in summer: still/draughty</td>
<td>Control over lighting</td>
</tr>
<tr>
<td>Air in winter: odourless/smelly</td>
<td>Air in winter: dry/humid</td>
<td>Control over noise</td>
</tr>
<tr>
<td>Air in winter overall</td>
<td>Control over cooling</td>
<td>Control over ventilation</td>
</tr>
<tr>
<td>Cleaning</td>
<td>Lighting: artificial light</td>
<td>Noise: noise from colleagues</td>
</tr>
<tr>
<td>Comfort: overall</td>
<td>Noise: other noise from inside</td>
<td>Lighting: natural light</td>
</tr>
<tr>
<td>Design</td>
<td>Noise: noise from other people</td>
<td>Lighting: glare from sun and sky</td>
</tr>
<tr>
<td>Effectiveness of response to requests for changes</td>
<td>Temperature in summer: hot/cold</td>
<td>Noise: noise from outside</td>
</tr>
<tr>
<td>Furniture</td>
<td>Temperature in summer: stable/varies</td>
<td></td>
</tr>
<tr>
<td>Health (perceived)</td>
<td>Temperature in winter: hot/cold</td>
<td></td>
</tr>
<tr>
<td>Image to visitors</td>
<td>Temperature in winter: stable/varies</td>
<td></td>
</tr>
<tr>
<td>Lighting: glare from lights</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lighting: overall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meeting rooms: overall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Needs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise: unwanted interruptions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise: overall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Productivity (perceived)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal safety in building and its vicinity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Space in the building</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Space at desk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed of response to requests for changes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage space: overall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in summer: overall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in winter: overall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do facilities meet user needs?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Areas for further investigation**

- Sustainable Head Office
- Do facilities meet user needs?
BUS Results Summary

High levels of positive feedback reflected in results
- High levels of comfort
- IT facilities good
- Good to have all staff in one place
- Building image good, bright, airy, ‘comfortable and inspirational’

Areas not performing as well:
- Perceived overcrowding and shared facilities (40% increase in staff although building still below capacity)
- Lack of control – building is not designed for high levels of user control/open plan office
- Draughts in winter (localised areas identified in smoke test)
- Glare & Noise (Localised and dependent on job type)
- Desk Space and Lack of Storage (Localised and dependent on job type)
Energy Performance

Energy Consumed Year 1 and Year 2

Energy Costs Year 1 and Year 2 (£)

CO2 Emissions Year 1 and Year 2

Energy Consumption 2013-2014

- Electric
- Oil
- Biomass
ENERGY DATA KEY FINDINGS

- Electricity increased by 5% in Year 2 from Year 1
- Staff numbers on site increased by 40% from Year 1 to Year 2 of the project
- Temporary offices installed to house additional staff working on specific project in Year 2
- A steady increase has been visible month on month for electricity – server room and small power
- Fossil fuel usage was down 32% in Year 2 from Year 1. This was a combination of more efficient use of heating controls and a milder winter
- Biomass boiler used for shorter time in Year 2 than Year 1 – decision to make changeover from Oil was delayed
- Boiler optimisation of BMS was switching boiler on over weekends and for longer periods than necessary – this was addressed in Year 2 and savings in fossil fuel were achieved
Biomass Lessons Learned

The Biomass boiler has been a success overall and has resulted in financial savings and lower carbon emissions.

<table>
<thead>
<tr>
<th>Biomass/Oil</th>
<th>Year 1</th>
<th>Year 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost Savings</td>
<td>£8,900</td>
<td>£3,250</td>
</tr>
<tr>
<td>CO₂ Savings</td>
<td>58 tonnes</td>
<td>31 tonnes</td>
</tr>
</tbody>
</table>

- Requires user knowledge and maintenance
- Cleaning once a fortnight, adequate storage
- Decision to changeover from Oil to Biomass user dependent
- Good price agreed with reliable local supplier

Improvements
Two smaller Biomass boilers may have enabled increased usage in summer months
RHI would have been an additional incentive – building doesn’t qualify (too early)
Boiler optimisation programme not always most efficient – human intervention required
ELECTRICAL CONSUMPTION

Electricity Consumption by End Use 2012/2013

Electricity Consumption by end use 2013/2014

- Lighting
- Small Power
- External Lighting
- Air Conditioning
- Lift
- Kitchen
- IT Server Room
- Fans/Pumps/Controls
- Access Control System
- Rain Water Harvesting
- Power to Future Workshop
- Electricity not submetered
## PERFORMANCE AGAINST ECON 19 BENCHMARKS

<table>
<thead>
<tr>
<th>kWh/m²/annum</th>
<th>Graham Performance Year 1</th>
<th>Graham Performance Year 2</th>
<th>Econ 19 Nat Vent Open Plan (2) Good Practice - Typical</th>
<th>Econ 19 Air Con (3) Good Practice - Typical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>78.85*</td>
<td>71*</td>
<td>54-85</td>
<td>128-226</td>
</tr>
<tr>
<td></td>
<td>(120.88)</td>
<td>(127.49)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating and Hot Water</td>
<td>130.86</td>
<td>98.81</td>
<td>79-151</td>
<td>97-178</td>
</tr>
<tr>
<td>Cooling</td>
<td>2.73</td>
<td>3.03</td>
<td>1-2</td>
<td>14-31</td>
</tr>
<tr>
<td>Lighting</td>
<td>18.6</td>
<td>18.54</td>
<td>22-38</td>
<td>27-54</td>
</tr>
<tr>
<td>Fans/Pumps/Controls</td>
<td>3.95</td>
<td>4.09</td>
<td>4-8</td>
<td>30-60</td>
</tr>
<tr>
<td>Office Equipment</td>
<td>28.13</td>
<td>27.2</td>
<td>20-27</td>
<td>23-31</td>
</tr>
<tr>
<td>Catering</td>
<td>7.49</td>
<td>7.18</td>
<td>3-5</td>
<td>5-6</td>
</tr>
</tbody>
</table>

* This is the energy use after the server room and external areas are removed as per ECON 19 and DEC recommendations
- C1 Rating
- Excluded Future Workshop and IT Server Room (34% of total electricity consumption)
- If Biomass not used rating would have been a D rating
- Improvements are possible
- C1 is a good rating
ENVIRONMENTAL MONITORING

[Graph showing time series data for various sensors, monitoring CO2 levels on different floors.]

Monday 11 February 2013

- Gnd Floor West 1.1 CO2 (ppm CO2)
- Gnd Floor East 1.3 CO2 (ppm CO2)
- 2nd Floor West 3.1 CO2 (ppm CO2)
- 1st Floor East 2.4 CO2

[pic of a sustainable building with the text Sustainable Head Office]
University of Ulster’s Thermal Mannequin ‘Pamela’ - used to measure thermal comfort and collect data on thermal environments
• Located in six different locations in the building
• Results demonstrated that a naturally ventilated office can operate with an acceptable temperature profile
• Mannequin detected acceptable comfort temperatures throughout but did detect issues on lower ground floor (confirming draughts/smoke test results?)
OPERATIONAL AND TECHNICAL ISSUES

• Data Collection and Meter readings - meters were not commissioned properly at handover and data was not always reliable
• The BMS and TEM system could be used in a more active rather then re-active way to save energy
• Choice to have a sliding door at reception rather than a revolving door has resulted in draughts on the ground floor which has affected user comfort and resulted in more radiators being installed
• Building fabric performed quite well and thermal mass of concrete pillars and ceiling appears to have had a stabilising effect on internal temperatures
• Temperature setpoints are higher than recommended 21 degrees but occupant satisfaction is the driver for this
• External document storage resulted in increased energy use due to heating external portacabins - unknown at beginning of project
How do we bridge the Performance Gap?

Energy Management

• Energy performance is between typical and best practice. Room for improvement
• Commitment made at design stage for a low carbon building needs to be carried through to operation of the building - energy management activities and a formal energy policy could help drive improvements – formally appoint an energy manager
• Bring Biomass boiler on line earlier in the season and leave on later to maximise CO2 savings
• Out of hours energy usage is high and savings could be made through simple housekeeping

Investment

• Manual lighting controls and daylight sensors
• IT – server rooms and small power continue to be a challenge, investigate alternatives
• Explore alternative options for storage of documents – Already Done
• Renewable energy options to further reduce CO2

Maintain high user satisfaction whilst reducing energy use
Drivers for bridging the Performance Gap

**Economic**
- GRAHAM Turnover 2014 – £418 Million
  - Staff Costs - £56 Million
  - Energy Costs @ Head Office £60k (0.014% turnover), (0.1% of staff costs)

**Environmental**
- Benchmarks?
- Certification Schemes?
- Awards?
- Regulation?
WIDER LESSONS

• Award winning low carbon buildings will not achieve results by themselves - management and operation of buildings is key.
• Monitoring equipment - meters and automatic controls can be unreliable and expensive to maintain. Commissioning and maintenance is critical.
• IT equipment and electronic devices are used ever more increasingly in office environments. This presents a real challenge for saving energy in a rapidly expanding business.
• Since beginning the project GRAHAM have increased staff numbers by 40% at the HQ site. Building in flexibility/room for expansion and storage need proper consideration at design stage.
• Biomass boilers often receive criticism however GRAHAM HQ shows this type of system can be used effectively with good results when operated and well maintained.
• The BPE Process requires commitment but does yield useful results. If the process can be streamlined greater uptake of BPE is possible.
WERE THE ORIGINAL OBJECTIVES MET?

GRAHAM set the brief with the following core aims and objectives:

• To provide a comfortable and inspiring work environment for staff
• To make the building as sustainable as possible.
• To make it affordable
• To be able to use it as a ‘good practice’ demonstration case study
FUTURE PLANS
Thank you