The Woodland Trust interior staircase

TREES OF KNOWLEDGE

Experience gained from the post-occupancy evaluation of the National Trust's Heelis building have been fed into the design of The Woodland Trust's headquarters. The project team compares the in-use performance of both

By Bill Bordass, Pete Burgon, Hester Brough, and Matt Vaudin

To maintain the 'golden thread' from design intent to reality when creating the 2,727m^2 head office for The Woodland Trust, Max Fordham – and architect Feilden Clegg Bradley Studios – used post-occupancy findings from the Heelis building, in Swindon. The outcomes have now been studied, thanks to funding from Innovate UK – formerly the Technology Strategy Board – and its Building Performance Evaluation programme.

In 2002-04, the environmental engineer and architect formed part of a research team investigating the potential for soft landings[1], and discovered the importance of maintaining the 'golden thread' – starting with inception and briefing, then managing expectations throughout the procurement process, building on initial aftercare, post-occupancy evaluation, and closing the feedback loop.

Gathering data

At that time, Max Fordham and Feilden Clegg Bradley Studios were working together on Heelis, the National Trust's 7,605m^2 (gross) head office in Swindon. The project followed a strong sustainability agenda, though this was somewhat softened by the requirements of the developer, which procured the building after the scheme design had been agreed with the client.

As part of the reality checking advocated by soft landings, a matrix was developed by Feilden Clegg Bradley Studios and Max Fordham, to allow design ambitions for

The Woodland Trust's head office, in Grantham

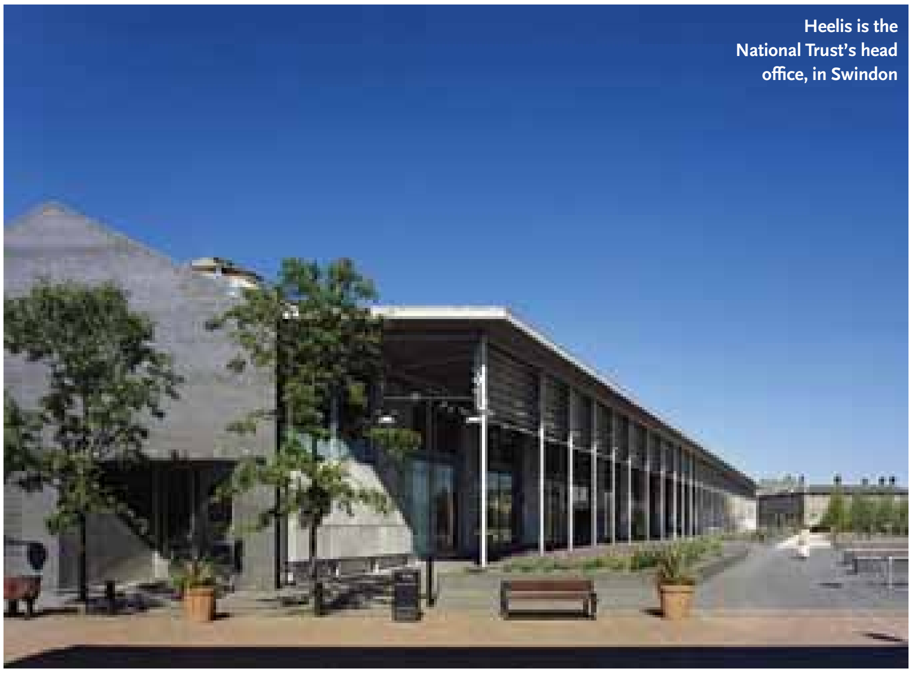
sustainability to be reviewed at project meetings. Max Fordham was also appointed to fine-tune the operation of the mixed-mode building for two years after handover. The Heelis findings were published in *Building Services Journal*[2] in November 2007.

Feilden Clegg Bradley Studios also commissioned William Bordass Associates and Building Use Studies to undertake a post-occupancy review, similar to the Probe studies published in *Building Services Journal* from 1995-2002[3].

Learning from Heelis

A key finding from Heelis was to avoid unmanageable complications. Measures adopted at The Woodland Trust included:

- A traditional contract. The developer-led procurement at Heelis did not allow some elements to evolve as the designers would have preferred



Heelis is the National Trust's head office, in Swindon

- The steel frame of Heelis had problems with airtightness and thermal bridging. The Woodland Trust, therefore, used a solid, cross-laminated timber (CLT) structure, with external wood-fibre insulation and larch rain-screen cladding. Concrete panels (known as concrete radiators) were also bolted onto the undersides of the CLT floors, to add stiffness and thermal capacity
- Heelis was mixed-mode, with windows that open, automated night ventilation – using motorised inlet panels and the negative pressure roof outlets – and background MVHR in winter. The Woodland Trust used natural ventilation only, with manual windows at desk level and motorised ones at higher level
- Heelis had suspended and recessed ceiling-mounted fittings, with occupancy sensing and dimming. The Woodland Trust had a simpler system, with ambient lighting controlled by an area time switch – or from reception – and task lighting by occupants. Corridors, stairs, WCs, and support spaces used self-contained occupancy sensors. Meeting rooms had manual controls
- The design at Heelis optimised daylight factors (see panel, 'Atrium at Heelis', right), but took less account of the brightness of walls and ceilings. As a result, some areas could feel gloomy when desktop illuminances were sufficient. Ambient lighting at The Woodland Trust, therefore, included wall-washing (see panel, 'Woodland Trust: North Atrium', page 22)
- The catering kitchen at Heelis used considerably more energy than anticipated. The Woodland Trust decided not to have one

ATRIUM AT HEELIS

This two-storey building relies extensively on roof lights – not just in the atrium, but in the office spaces around it, where there are also openings between the first and ground floors. The roof includes automatically controlled ventilation openings designed to achieve negative pressure under all wind directions, and an 83kWp photovoltaic (PV) array. Note the external louvres to the south-facing offices to the right. Roof lights to the office areas are north-facing only, shaded by projections of the PV panels above the ridge.

The Woodland Trust has a solid, cross-laminated timber structure, with external wood-fibre insulation and larch cladding

> The 'keep it simple and do it well' approach could be taken further still, particularly by improving the usability of control systems and avoiding over-complication in the name of energy efficiency

THE WOODLAND TRUST: NORTH ATRIUM

Note the central steel columns and beams, and the concrete radiators to the left and in the background. Wall-washing lights can be seen on the west wall, with ambient lighting up the centre. The few splashes of light on the ceilings indicate that most of the task lights were off.

- The ICT system at Heelis had used more electricity than anticipated. The Woodland Trust, therefore, chose 'thin clients' in place of PCs. This – and good use of daylight – also helped to reduce unwanted heat gains into the office space
- Both server rooms combined chilled water systems with free cooling. However, value engineering at The Woodland Trust changed this from airside to waterside free cooling
- Both buildings had relatively standard heating systems, with three gas boilers, perimeter trench heating – with a compensated flow temperature – and local zoning, using two-port valves. The Woodland Trust's plant was more compact and efficient, with lightweight condensing boilers. Heelis had cast-iron boilers, with only one condensing
- At Heelis, using the heating plant to produce domestic hot water (DHW) proved inefficient in summer, so the post-occupancy evaluation suggested an independent hot water boiler. The designers did not take up this recommendation for The Woodland Trust, as it had more efficient plant, and no catering kitchen.

Occupant satisfaction

Figure 1 compares average scores for headline indicators from the BUS Methodology occupant questionnaire surveys. The satisfaction scales run from 1 (poor, on the left) to 7 (good), apart from the final question – on perceived productivity – which goes from -40% to +40%. The flashes above each of the scales represents the benchmark from the BUS reference dataset for that variable, with the 95% confidence limits. The points are coloured red if they are statistically significantly below the benchmark, green if they are above, and orange if similar. For consistency, BUS 2011 office benchmarks are used for both buildings (2004 benchmarks were originally used for Heelis).

The profiles are similar for both buildings. In detail:

- Heelis rated worse on winter temperature and summer air quality. This partly related to initial control problems. The situation was improved the following year
- The lower perceived productivity at Heelis was probably because many staff had relocated from other parts of the country. The Woodland Trust moved just 200 metres
- Noise at The Woodland Trust was the only indicator significantly worse than average. This reflects a general deterioration in noise perceptions, owing to more open planning, and higher occupation densities. Many Trust staff were also unaccustomed to open-plan offices. In addition, The Woodland Trust needed to use a space that was acoustically connected to the offices for large meetings and training sessions – activities not anticipated in the brief
- The average score for health at the Trust was linked to less window opening than anticipated, and – perhaps – some initial problems with outgassing. Ventilation control was subsequently improved.

Energy performance

Using standard Building Regulations assumptions, the predicted annual gas consumption was 37.5kWh/m^2 GIA at The Woodland Trust. The total in 2012-13 was

32.6kWh/m^2, with the heating component, 25.7kWh/m^2, almost identical to the design estimate – a very good result in this exceptionally cold year. This also compared well with the 90kWh/m^2 for heating and hot water at Heelis, with an additional 24kWh/m^2 for its catering kitchen.

Figure 2 shows annual electricity consumption – in kWh/m^2 –for the same period, broken down by end use. Starting at the bottom, this shows:

- The estimated breakdown for Heelis in 2006. Note the large proportion attributable to the server room and catering kitchen. Not shown is its 9kWh/m^2 renewable contribution from PV
- The design estimate for The Woodland Trust, using standard assumptions for Building Regulations, plus Max Fordham's estimates for the server room
- In-use performance at the Trust in 2012-13. Note the much lower consumption of the lighting and the ICT in relation to the small power allowance. However, much of this reduction reappeared in the server room and its air-conditioning
- Potential future savings using relatively low-cost measures – predominantly switching off the VoIP telephones outside office hours (plus associated savings on the switch, UPS and associated air conditioning), and improved control of the backup cooling units in the server room and the ambient lighting.

Issues in operation

Generally, The Woodland Trust building performed well, but some problems arose in use – of which server-room cooling was the most critical.

Value engineering at a relatively late stage replaced the independent airside and chilled water cooling systems with a packaged chiller, with both refrigerant and free cooling. Although the chiller was highly specified, it failed every few months, bringing down the Trust's entire ICT, thin client, and telephone systems.

The manufacturer was remote and local support proved difficult to obtain, so a basic DX backup system had to be added. The chiller's controls proved to be vulnerable to brief power interruptions, which are common in Grantham. Although the problems were eventually fixed, simple, more standard equipment would have been preferable.

Using the boiler plant for both heating and hot water also led to some energy wastage, because of interactions between the two systems. A reduction of nearly 10% in gas

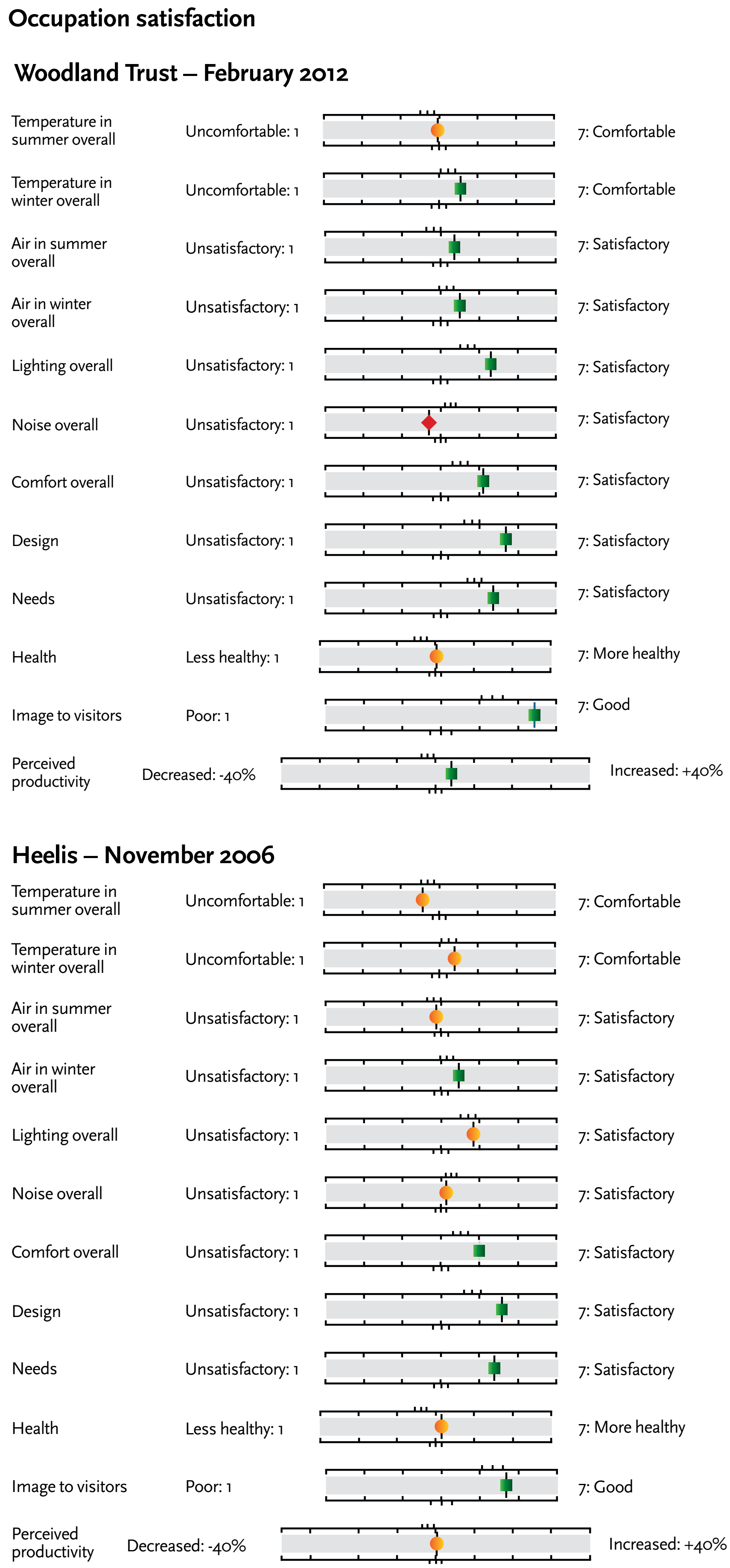


Figure 1: Comparison of average scores for headline indicators from the BUS Methodology occupant questionnaire surveys

consumption was estimated had the systems been completely separated.

The natural ventilation system initially caused problems. In winter, occupants opened windows less than expected because of draughts (the main openings are at desk level). When CO_2 levels rose above 1,200ppm, the automated system opened higher-level windows, but the minimum setting of 10% was also draughty. The BMS was eventually altered to give facilities control over minimum window opening.

In summer, night cooling was also disappointing initially, partly because of a complicated control logic and convection currents reaching the external air-temperature sensor when the sun's rays fell on the building's timber rain-screen cladding, elevating the detected temperature by as much as 8°C. The situation was improved by relocating the sensor, simplifying the logic, and allowing the facilities manager to decide whether heating or night cooling was required.

The function of the concrete radiators was explored in 2012-13, using heat-flux sensing and time-lapse infrared thermography. The average rate of heat absorption during office hours was 5W/m², rising to 10W/m² on hot days. An important finding was a need to close windows an hour before the office opened, so temperatures could equilibrate, otherwise the air and furniture could feel too cool when people arrived (see panel 'Night cooling and concrete radiators', right.)

Conclusions

The building achieved many of its design objectives: good quality at a normal cost (£1,800/m²), and good levels of occupant satisfaction – though with shortcomings in relation to noise, in particular. Initial problems with air quality and summertime temperature have been tackled, with potential for further fine-tuning.

Lower energy use than Heelis was achieved for all building-related end uses, especially heating and lighting. However, despite 'thin clients' and other efforts, the electricity used by ICT systems was higher. Future projects would benefit from the services of an ICT energy-efficiency consultant.

The 'keep it simple and do it well' approach could be taken further still, particularly by improving the usability of control systems, and avoiding over-complication in the name of energy efficiency – especially in the design of the server room cooling system. In terms of procurement, future projects should:

- Adopt soft landings and manage it firmly from the outset, with champions identified to carry it forward throughout a project
- Make better provision for follow-through after practical completion. Fine-tuning will always be necessary – this should be planned for, including a contingency budget to allow any minor alterations to be dealt with quickly and effectively
- Appreciate the need for constant feedback. With each project there are new things to learn; a problem addressed is not necessarily solved; and unintended consequences may emerge. **CJ**

Electricity consumption at Heelis and The Woodland Trust

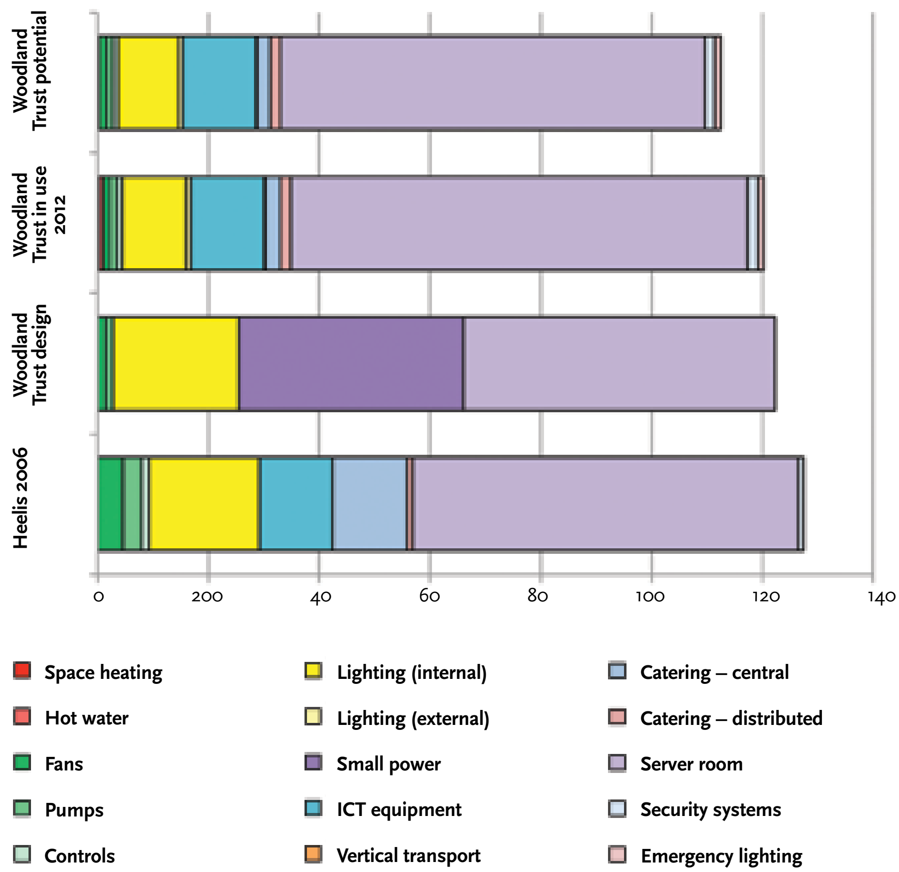


Figure 2: Annual electricity consumption kWh/m², broken down by end use

References:

1 The *Soft Landings Framework* published by BSRIA and UBT in 2009, drew upon this research work, subsequent case studies, and the activities of the user group hosted by BSRIA. Download it from **www.usablebuildings.co.uk**

2 G Nevill, *So, how are you doing?* Building Services, *Building Services Journal*, 32-37 (November 2007).

3 The original Probe articles can be downloaded at **www.cibse.org/knowledge/probe-post-occupancy-studies**

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NIGHT COOLING AND CONCRETE RADIATORS

The office at the end of a period of night cooling, showing heat retained in the concrete radiators while the rest of the office is cold. The interior, therefore, needed time to come to equilibrium before occupancy.