The following report is an official output from the Carbon Trust-funded Low Carbon Buildings Performance (LCBP) research programme 2006 - 2010. Twenty three projects were awarded DECC grants for testing the application of renewable energy systems in non-domestic buildings. Four building post-occupancy reports were written by BSRIA's Roderic Bunn in 2011. They were reported in *Building* magazine but never hosted anywhere else. Roderic Bunn has reproduced the original reports for the Usable Buildings Trust as free downloads.

Elizabeth II Court (East)

First published December 2011

by Roderic Bunn

Office refurbishments can't be judged by the same standards as new build. By definition, the retained elements of old buildings create physical constraints that have to be worked around, managed, or simply accepted as shortcomings. Good architects and engineers can hide them or reduce them, but they can't make them go away.

Elizabeth II Court in Winchester, an office refurbishment for Hampshire County Council (HCC), shows what is possible given enough time, budget, and a design brief that is informed by analysis and feedback from the existing building. Ambitions for energy use and occupant satisfaction were well informed and therefore realistic. The project therefore serves as a useful template for other refurbishment projects, particularly as the key to reducing carbon emissions from the build environment lies far more with retrofit than with new build.

Elizabeth II Court is HCC's former Ashburton Court site, which comprises North, West and East blocks on a podium car park. Hampshire County Council decided to refurbish the entire site, excluding parking, and turn it into an exemplar of sustainable and energy efficient office space.

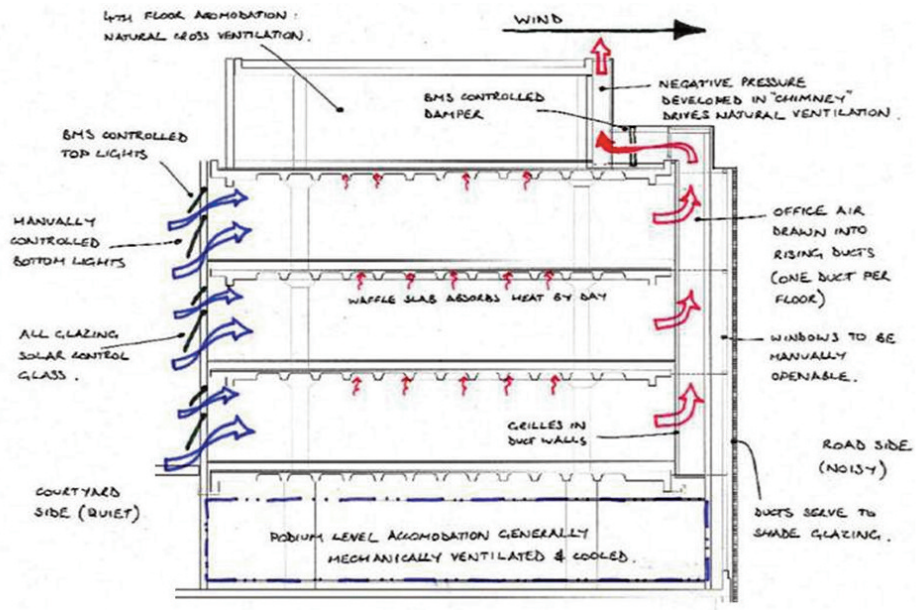
The three-storey East block, built in the 1960s, is typical of local authority offices of the period: heavyweight concrete construction with prefabricated concrete panels, and single-pane glazing with horizontally-pivoting openable windows for natural ventilation. The East block was studied under the Carbon' Trust's Low Carbon Buildings Accelerator (LCBA) research programme, and is referred to as such throughout this article.

Sustainability and energy efficiency were key project objectives for the refurbishment, which set out to meet, and in some areas exceed, the requirements of Part L of the 2006 Building Regulations.

HCC appointed Mace as project managers, with the design team led by architect Bennetts Associates with Ernest Griffiths as the building services consultant. The principal contractor was HBG. The Carbon Trust appointed Arup to monitor the project under the LCBA programme.

The condition and thermal performance of the fabric was poor by contemporary standards: overall façade U-values varied between 1.6 to 5 W/m²K. The building wasn't very airtight either. Lighting was also very typical: fluorescent luminaires fitted in a suspended ceiling. This not only hid the building services, but also disconnected the building's thermal mass from the occupied space. The lighting control zones were too large for any energy saving measures to be effective.

In 2006, a Building Use Studies (BUS) occupant satisfaction survey of the East block revealed extremely unhappy occupants. The building was ranked near the bottom of the BUS dataset, one of the lowest scores in 20 years of



surveys. People were highly uncomfortable in summer and winter, there was too much electric lighting and not enough natural light, and the offices were too noisy.

Procurement

The construction programme was phased to reduce the cost of decanting staff during construction. Staff continued to work in the North and West blocks while the East block was constructed during Phase 1. The North and West blocks were constructed over the following 18 months. The redeveloped 3000 m^2 East block was completed in December 2008.

The budget for the refurbishment of the entire site – the east and west blocks and the basement area, including fees, relocation and temporary accommodation- was fixed at £42 million. At the time, County residents were very concerned about the Council's expenditure on its own accommodation so this figure could not be exceeded.

The designers – architect Bennetts Associates, and Ernest Griffiths as the m&e consultant – were the only team to propose refurbishment of the buildings by taking them back to the structure and adding new facades and comfort systems.

The architect and the m&e consultant had worked together before, and were familiar with blending architecture and engineering. With committed players, the design team were also able to deal with the challenges thrown up by the project (such as cost, programme, logistics and value engineering). The m&e consultant also robustly defended key elements of the scheme in the face of pressure to value engineer the BMS, for example.

The project's scale, complexity and phased construction meant the early involvement of a major contractor to ensure that a collaborative approach was taken to the project's development. HBG was appointed as the principal contractor, with a two-stage contact, around the same time as the design team was providing a pre-construction service. The pre-construction service included the development of a package based procurement strategy based on the HCC trade contract framework agreement, and this helped to shape the detailed design programme. The pre-contract agreement was later converted into a standard JCT 98 contract form once the scope of work and associated costs were more defined.

The tender period was particularly challenging for the project team. There were many individual packages to consider. Time was limited and activities were taking place on all fronts simultaneously.

Refurbishment objectives

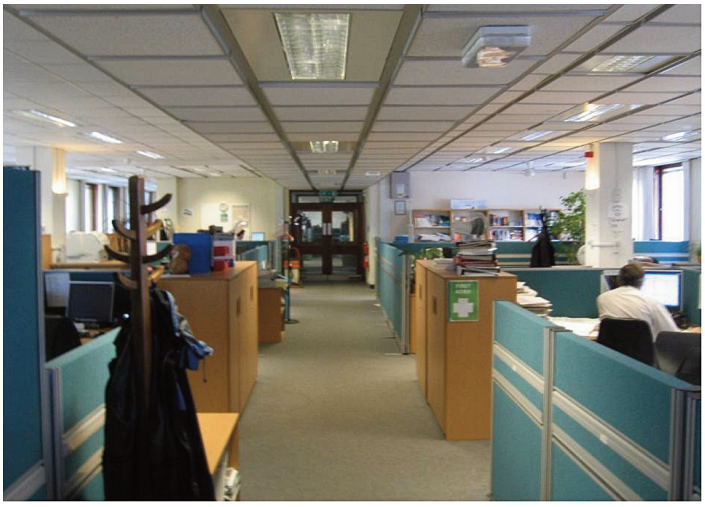
The form of the building, with long narrow floor plates and manageable floor to floor heights, lent itself to a low energy refurbishment. The design team wanted to establish an environmental strategy that was sufficiently robust and flexible to accommodate change with an emphasis placed on sound, environmental engineering rather than over reliance on sustainable technologies. The building services were to required to be simple, and without overly complex control systems.

The design team were appointed on the basis of the low energy refurbishment proposed in their bid. The design included a number of low carbon features from the outset including: improved building fabric, natural ventilation using a combination of chimneys and opening windows; night cooling; use of waste heat from the IT suite; and daylight and occupancy-linked efficient lighting.

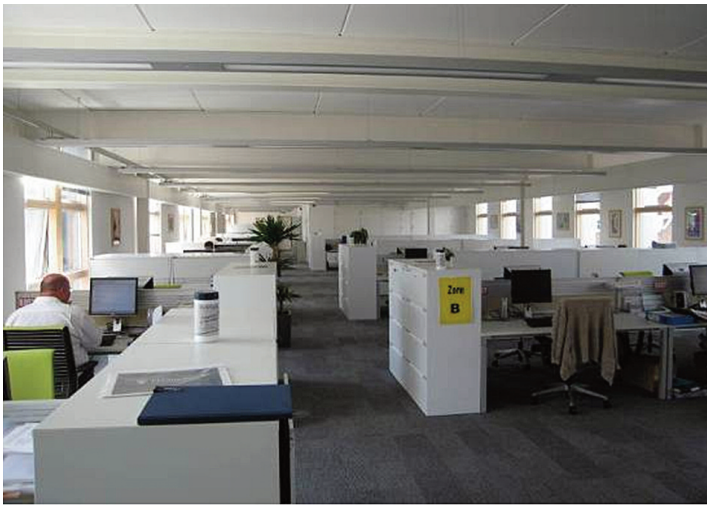
The design team were aided by the LCBA team, who reviewed and commented on the design proposals, including advising on sensible glazing ratios and suggesting ways to specify glazing performance and U-values. The LCBA team recommended that the specification for air permeability should be halved to 5 m^3/(h.m^2) at 50 Pa, and this was subsequently taken on board.

Early energy calculations suggested 59 kWh/m^2 per annum for fossil fuel, and 34 kWh/m^2 per annum for electricity. The targets were subsequently refined to 57 kWh/m^2 per annum for fossil fuel and 66 kWh/m^2 per annum for electricity. The combined carbon dioxide emission target of 39 kgCO_2/m^2 per annum was equivalent to a 10 per cent improvement over the *Energy Consumption Guide 19 (ECON 19)* good practice performance for a hybrid office, with a 15 per cent Type 3 component. The carbon dioxide emission target was subsequently reduced to 35 kgCO2/m^2 per annum as more information became available during design development.

When these targets are compared with the estimated figures for the old building – between 320-335 kWh/m^2 per annum for gas and electricity, and combined carbon emissions of 90-92 kgCO_2/m^2 per annum – the scale of the challenge set by Hampshire County Council becomes clear.



The offices prior to refurbishment in 2006



A similar view after refurbishment in 2010.

The main ways of reducing energy consumption were reduction of heat loss in winter, improving daylighting, cutting out solar gain and using natural ventilation where possible. The environmental services systems were selected on their energy efficiency ratings, and efforts were made to select effective controls, with simple systems that are easy of occupants to understand and use. The office equipment was not ignored, and HCC made efforts to specify energy-efficient office equipment. Waste heat from the data centre was also used to boost the heating systems.

Cost constraints limited the adoption of some renewable energy technologies. The most viable renewable measure, solar water heating for the central kitchen, was eventually value-engineered out. A central lighting control system was also ruled out early on because of concerns about escalating costs. Other measures survived, such as dimming, presence detection and photoelectric sensors on the office lighting. Variable-speed drives on the pumps and fans were retained as an intrinsic part of the design, as was the investment in full BMS functionality.

The LCBA team proposed a mechanical ventilation system to avoid the need to open windows in winter and to reduce the risk of complaints of draughts in perimeter zones. Although this increased fan power, the LCBA team saw it as essential in meeting the comfort and satisfaction needs of occupants.

The hybrid, mixed-mode approach was adopted and the design developed to so that fan energy consumption could be minimised. Each half of a floor plate is therefore served by small, low pressure loss air-handling units. The supply fans have variable speed drives controlled by carbon dioxide sensors, with switching based on time and outside air temperature. Vitiated air exits via the natural ventilation chimneys and the toilet extract fans.

Architecture

All the buildings on the Ashburton Court site were extensively remodelled. The top floors of the West and East blocks were cut-back to reduce the overall massing and to reduce the perceived height of the building. The car park space at podium level under the East block was changed to office accommodation, with the similar area under the West and North blocks used for a new IT suite and ancillary spaces. This included a new reception, a café and auditorium pavilions. These changes saw the accommodation increased from around 9000 m^2 to nearly 14,000 m^2, of which the east block represents about a quarter.

There are two main types of facade: the west facing street elevation of windows and brick-clad ventilation chimneys, and the courtyard-facing elevation of windows and aluminium panels. HBG took on responsibility for co-ordinating the contract packages for windows, panels, brickwork and chimneys. Two procurement routes were considered: an aluminium curtain walling system or a window and panel based system, such as Velfac. The Velfac option was selected because it was significantly cheaper.

Elizabeth II Court's elevations face East and West, which presented a challenge in terms of solar control. The facade design has attempted a high degree of self-shading. Glazing was selected to optimise solar control and light transmission properties. The large number of openable windows meant that air leakage performance needed to be good. Internal blinds (for solar and glare control) also needed to take account of natural air paths, so perforated blinds were used.

The floor-to-floor heights on the office floors vary around 3.35 m, as determined by the dimensions of the original structure. The removal of the suspended ceiling exposed the original concrete slab of 880 mm coffers, increased the effective floor to ceiling height, and released the thermal capacity of the building to assist in moderating internal temperatures. Cables and air supplies are now run within a 320 mm raised floor zone.

The standard layout of suspended light fittings in open plan office areas was changed in a couple of areas where alignment was an issue architecturally. For example the lighting in the bays between chimneys and the area in front of the air handling plant rooms was provided by circular drum fittings rather than raft fittings.

The typical net usable open plan area is around 7 m^2 per person, with the typical net internal provision around 13 m^2 per person.

Environmental engineering

The m&e consultant took a pragmatic approach to low energy design. The original concept design included a number of good low energy features, such as reasonable levels of glazing, natural ventilation, and daylight and presence control of lighting. All these features contributed to a building with low energy potential.

With sustainable design it's crucial to get the basics right. The designers recognised that the refurbishment nature of the project would create constraints (particularly energy

consumption and summertime temperatures) compared with a new building on a greenfield site. Elizabeth II Court's orientation, with predominantly East and West-facing facades, limited the effectiveness of external shading (especially at lower sun incidences).

The top floor of the East block is well above street level and facades are set back. This enables it to be cross-ventilated on both sides of the building. The wind-driven cross-ventilation makes good use of the pressure differentials developed across the top of the building.

On the lower floors, the street elevation is equipped with ventilation chimneys, located at regular intervals along the facade. Each extract chimney serves one of the three lower floors. An offset at the top of each chimney prevents rain penetration, improves the acoustic properties, and provides a location for a vertical motorised opening sash.

The cross-sectional area of the chimneys (950 by 650 mm) is critical to the performance of the natural ventilation system. The grilles at each storey level are 1.5 m by 0.6 m, with 70 per cent free area. The window bays on the courtyard façade have a 600 mm-high, BMS-controlled motorised toplight that can be opened to give a free area of 50 per cent. The lower windows can be opened manually to a free area of 30 per cent.

The motorised windows and the chimney sashes are automatically controlled to vary the amount of natural ventilation. Local manual overrides are provided for each group of automatic windows and chimney sashes (with BMS override to limit the period of manual operation).

The lights and chimney sashes are automatically opened in summer whenever room temperature exceeds 16°C, day or night or when carbon dioxide levels reach certain levels. They are also opened at night by the BMS for night purging when external temperatures exceed set levels, taking advantage of the thermal mass of the exposed concrete soffits.

Openable windows have been provided to give occupants the freedom to control their ventilation needs, enabling them to trade off air movement, temperature, air quality and outside noise as they see fit. This acknowledges that occupants are more likely to be happier with conditions that are just about right with some means of control, than with instrumented conditions and no means of control.

The mixed-mode mechanical ventilation system is used to deliver minimum outdoor air ventilation during colder weather and also during hot weather. A small supply air-handling unit is provided at each level, adjacent to each core. Supply fans are speed-controlled, and controlled on carbon dioxide readings. Supply air is filtered, heated if necessary and ducted into the floor void.

Waste heat from the data centre is the principle source of heating to office areas. The waste heat is only topped up by the boilers when external conditions dictate. Much of the ventilation heating load is satisfied by waste heat from the data centre, so there is no need for exhaust heat recovery (and therefore no additional fan pressure drops.)

Each partitioned room has a small fan under the floor, which draws air from the adjacent open plan floor void and supplies the room via floor diffusers. Extract air is exhausted naturally via the chimneys and via copier/toilet extract systems.

The heating system is served by low temperature hot water, provided by three gas-fired condensing boilers. Under normal operating conditions two boilers satisfy demand.

Office areas are heated by perimeter radiators fitted with thermostatic radiator valves. Partitioned rooms are heated by heat recovery VRV units, controlled by wall-mounted controllers. A significant change from the early design were the introduction of meeting rooms and a few cellular offices - a reflection of HCC departmental changes. This meant that more VRV units and associated underfloor supply fans were required.

Lighting in the open-plan office areas relies on suspended fluorescent fittings with an element of up-lighting to illuminate the exposed waffle slab. The luminaires are arranged in rows across the width of the building at about 2.6 m intervals to coincide with the spacing of the waffles.

Each section of light fittings have a passive infrared detector and a programmable light level sensor. The lamps are dimmed down to off when an area is unoccupied for more than a predetermined, programmable period. There are no manual switches, nor is there a no central control system.

An IT hub room has been located in the north core of the East block, with patch panels on each floor. All other server equipment is located in the data centre.

Preparation for handover

The Carbon Trust's LCBA team stressed that a commissioning plan should be prepared by the commissioning manager, who needed to be appointed early. In the event, a commissioning specialist was appointed much later than planned, so HBG prepared an initial commissioning programme covering a scope of work up to and beyond practical completion.

HBG's project director asked the commissioning specialist to produce a very aggressive programme for commissioning. As a result commissioning remained in a state of flux until practical completion. While the building services team was united in defending a sensible timeframe for commissioning, the non-building services members of the project team (in both HCC and HBG) tended to regard commissioning as a cause for delay rather than an essential precursor to a successful building There was also much debate about what constituted commissioning compared with fine-tuning during the post-occupancy period.

The original commissioning programme was revised on 15 October 2007. After that, some of the key building milestones were not met and this adversely affected the commissioning programme. Practical completion was originally due on the 21 December 2007 and was moved to 4 January 2008. This was subsequently moved back to 18 January 2008.

In the project brief HCC identified that fully co-ordinated O&M manuals should be provided in electronic format with a simple user-friendly access system. The LCBA team pointed out that full O&M information should be available in advance of handover so that HCC's facilities staff could familiarise themselves with the systems. The preliminary O&M manuals were fairly conventional in terms of scope and form, but not especially user-friendly. HCC subsequently received more user-friendly manuals.

HCC prepared a 30-page booklet Ashburton Court East – A guide for staff. The guide included space plans, types of work space and office equipment. Only one page covered the heating, ventilation and lighting systems. The LCBA team

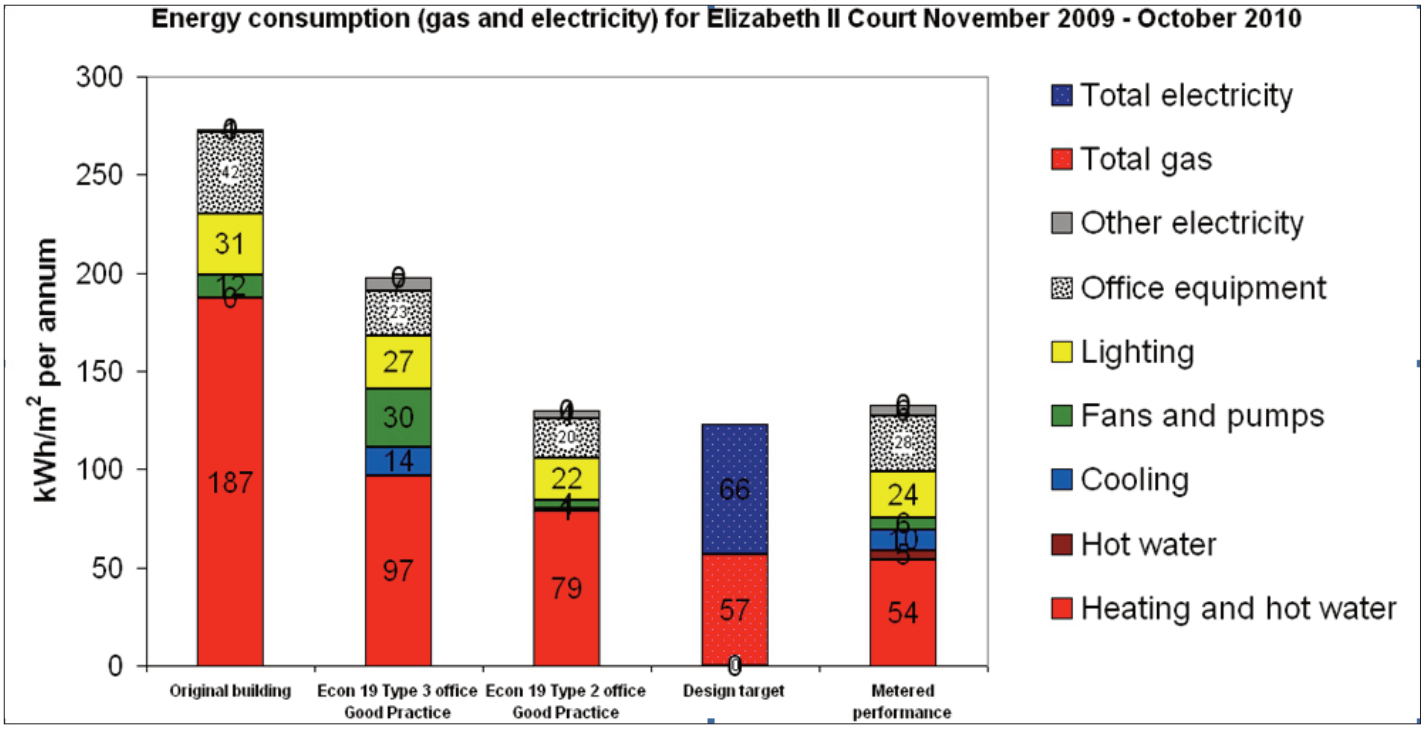


Figure 1: Energy performance of the East block at Elizabeth II Court compared with design modelling and the relevant benchmarks from Energy Consumption Guide 19 (ECON 19). The treated floor area is 3185 m2.

Elizabeth 2 Court (East block) energy consumption in kWh/m² per annum (3185 m2 TFA)

	Econ 19 Type 3 Good practice	Econ 19 Type 2 Good practice	Original building metered	Original building modelled	Business as usual* model	Design Target	LCBA Phase 2 model	LCBA Phase 3 model	*Metered data
Heating and hot Water	97	79	187	300	56		28	39	54
Hot water							1	1	5
Cooling	14	1	0	0	12		4	7	10
Fans and pumps	30	4	12	45	28		3	4	6
Lighting	27	22	31	27	25		26	24	24
Office equipment	23	20	42	15	30		33	29	28
Other electricity	7	4	1	0	2		1	1	6
Total gas	**97**	**79**	**187**	**300**	**56**	**57**	**28**	**39**	**54**
Total electricity	**101**	**51**	**86**	**87**	**97**	**66**	**68**	**66**	**77**
Total	**198**	**130**	**273**	**387**	**153**	**123**	**96**	**105**	**131**

Elizabeth 2 Court carbon dioxide emissions in $kgCO_2/m^2$ per annum

Gas	19	15	36	58	11	11	5	8	10
Electricity	43	22	36	37	41	28	29	28	33
**Total	**61**	**37**	**73**	**95**	**52**	**39**	**34**	**35**	**43**

*Monitoring from November 2009 to October 2010.
**At carbon factors of 0.194 for gas and 0.422 for electricity

recommended that the guide should be supplemented by more information on the services systems, and written in a way that could be easily understood by non-engineers.

Initial building performance

The East block of Elizabeth II Court was completed in December 2008. Hampshire County Council (HCC) and the Carbon Trust team carried out performance monitoring of this block during a 12-month period, from November 2009 to October 2010.

It is important to stress that energy measurements in the first 18 months will not be representative of a building's long-term performance. There are many variables: outstanding defects, delayed commissioning, phased occupation, and fine-tuning of systems to suit occupants' needs. Readers should therefore reserve judgement on whether or not the building has achieved its environmental targets.

The East block has extensive metering, such as heat metering for the hot water circuits and data centre waste-heat circuits. The temperature of the exposed concrete slab is monitored, as is the exhaust air flow in a chimney serving a typical area on the first floor. This is used to assess the performance of the night cooling process.

It was not all plain sailing. A problem with the selection of the original gas sub-meter for the boilers could not be resolved and a meter was not installed. The monitoring functionality of the VRV system central supervisor was also less than originally planned. Proposed electricity meters for monitoring the use of lighting in staircases and toilet lobbies were also not installed as planned.

A delay to the start of monitoring and problems with data collection meant that the original programme was changed to include a three-month initial period of 'light touch' monitoring, starting in November 2009. This period was eventually extended seven months to May 2010, followed by two months of detailed monitoring in June and July 2010. A final three months of light touch monitoring ran up to October 2010.

Energy and carbon dioxide

As the refurbished East block has mixed-mode ventilation and some mechanical cooling, no direct equivalent energy or carbon performance benchmark is available. The initial design target was therefore based on a hybrid of the Good Practice Type 2 and Type 3 office benchmarks in *Energy Consumption Guide 19* (*ECON 19*). This led to an agreed notional energy target of 57 kWh/m² per annum for fossil fuels and 66 kWh/m² per annum for electricity.

At carbon factors of 0.194 for gas and 0.422 for electricity (to maintain consistency with *Part L*) the target carbon dioxide emissions were 39 $kgCO_2/m^2$ per annum. This target was subsequently reduced to 35 $kgCO_2/m^2$ per annum as

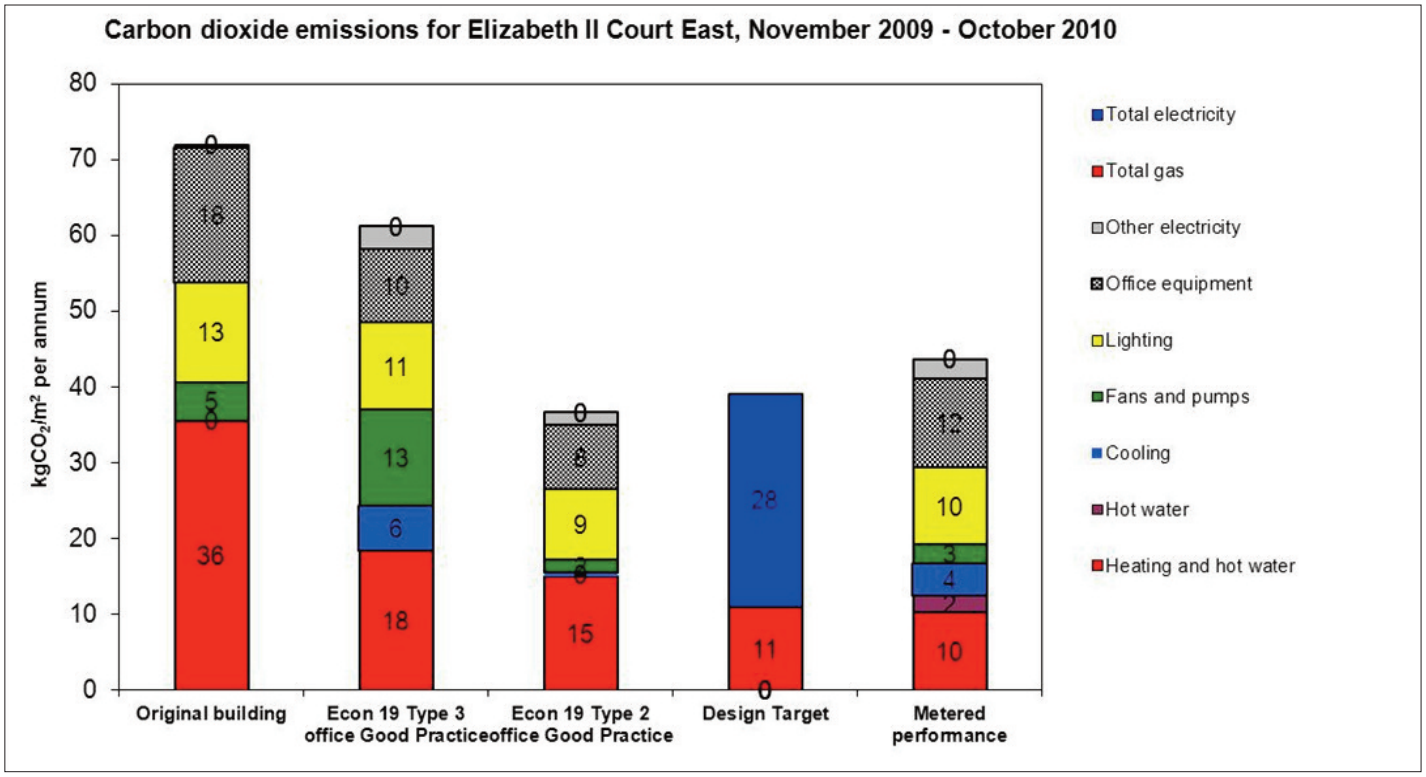


Figure 2: The carbon dioxide emissions for the East block at Elizabeth II Court, based on data in figure 1. The carbon factors used to calculate emissions were 0.194 for fossil fuel (gas) and 0.422 for electricity. The treated floor area is 3185 m2.

more information became available during design development.

The 12 month monitored results have come in at 131 kWh/m^2 per annum, 7 per cent higher than the original design target. Figure 1 shows how the energy consumption breaks down by end use.

At 77 kWh/m^2 per annum, the total electrical consumption of the East block of Elizabeth II Court is around 17 per cent higher than the original design target. For lighting, the average monthly consumption is around 5700 kWh, or 21.9 kWh/m^2 per annum. Including an adjustment factor of 1.4 kWh/m^2 per annum for the lighting in the stairs and stair lobbies, the corrected annual consumption is 23.3 kWh/m^2 per annum. Domestic hot water electrical consumption is 4.6 kWh/m^2 per annum (close to the good practice benchmark), cooling close to 10 kWh/m^2 per annum, and fans and pumps 5.6 kWh/m^2 per annum, with a proportion of this caused by pumping for heat reclaim.

With gas consumption at 54 kWh/m^2 per annum, the East block of Elizabeth II Court is achieving slightly better than the original design target. This excludes heat reclaim – equivalent to around 17 kWh/m^2 per annum). The Carbon Trust's LCBA advisory team believes that savings of 11-21 kWh/m^2 per annum could be made, for example by reducing heating during summer and by fine-tuning the interaction between heating and natural ventilation throughout the year. With these measures consumption could be brought down to 43-33 kWh/m^2 per annum.

At 43 kgCO$_2$/m^2 per annum, the carbon dioxide emissions, over the 12-month monitoring period, were 10 per cent higher than the initial target, (and about 20 per cent higher than the LCBA team had modelled), so there is scope for improvement (Figure 2). HCC's head of engineering services, Steve Hall, has recognised that even a few people working in the building on a Saturday tends to bring on the central systems. "We know that energy use on a Saturday is 50 per cent of a typical day," he said. "The mechanical ventilation, the water heaters and the chillers can all be on, even though levels of carbon dioxide are never going exceed any comfort thresholds". HCC plans to alter the ventilation strategy so that low occupancy for short periods does not bring on the mechanical ventilation.

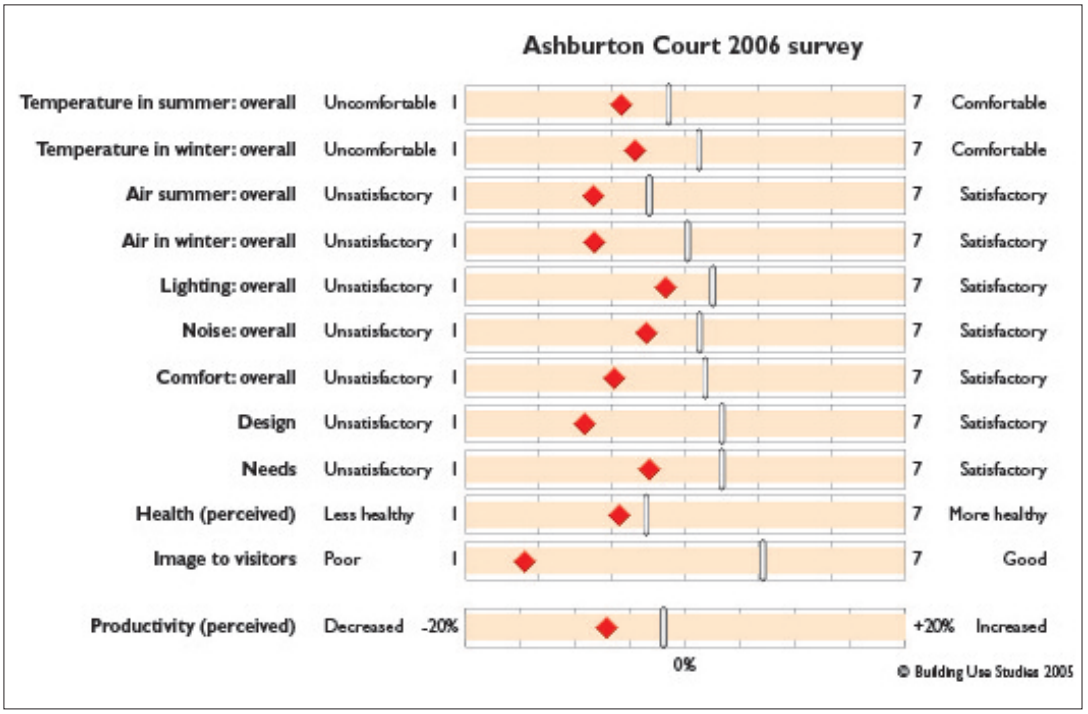
Occupant survey results

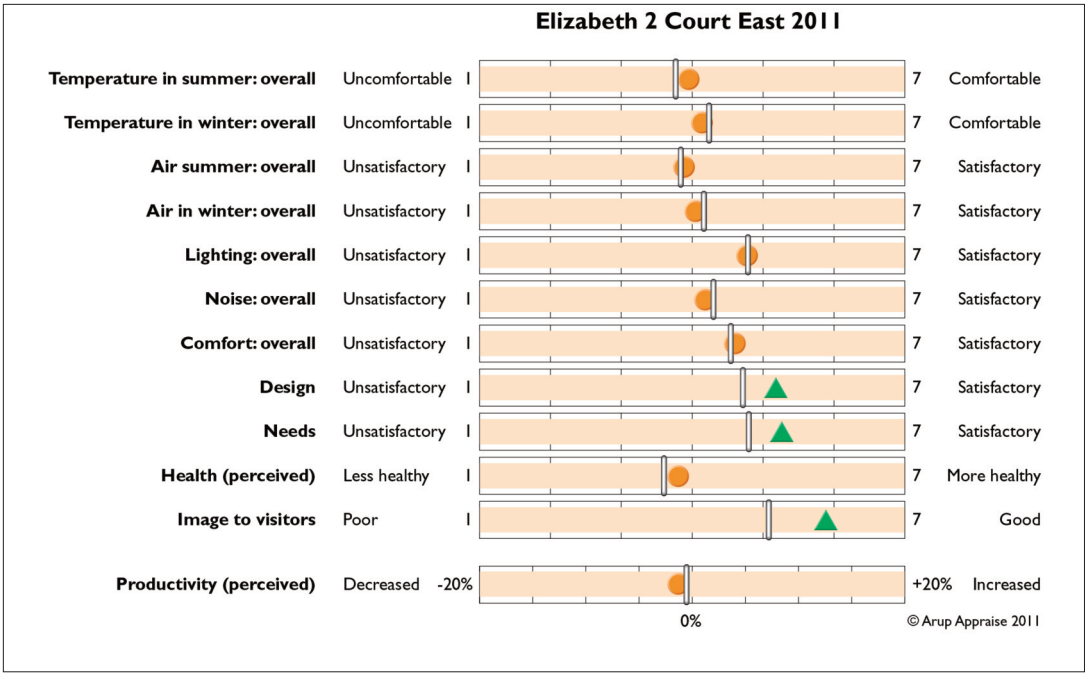
Occupants satisfaction with the East block of Elizabeth II Court, before and after refurbishment, was measured by using the Building Use Studies (BUS) occupant satisfaction survey.

The original building was very poorly received by users and was ranked near the bottom of the UK benchmark dataset, one of the lowest scores in 20 years of surveys (Figure 3). The internal temperature in the offices on the first floor reached 34°C in July. It was judged to be uncomfortable both in summer and winter with poor control over heating. There was too much artificial light, not enough natural light, and it was too noisy. There was high dissatisfaction overall, and perceived productivity was also low.

A second BUS occupant survey was carried out in July 2010 by consultant Arup, under its Arup Appraise service (Figure 4). The 12 summary variables show a huge improvement in the occupants' view of the refurbished building. It now scores particularly well in terms of design, occupant needs, and image.

In summer, the control of temperature is generally acceptable, in the range 22-26°C for most of the time during working hours. Control of the peak operational temperature (the comfort temperature experienced by occupants) could be improved by optimising night cooling. Additional fine-tuning will be carried out in the summer of 2011.





Green triangles represent mean values significantly better or higher than both the benchmark and scale midpoint. Amber circles are mean values no different from benchmark. Red diamonds are mean values worse or lower than benchmark and scale midpoint. The UK benchmarks are represented by the white line through each variable.

Be careful to read the directions of the scales and the scale labels.

Figure 3: The occupant satisfaction performance of the East block before and after refurbishment was compared by survey and assessed using the BUS methodology. The original building was very poorly received by users and was ranked near the bottom of the UK benchmark data, one of the lowest scores in 20 years of surveys. The internal temperature in the offices on the first floor reached 34°C in July. It was judged to be uncomfortable both in summer and winter with poor control over heating. There was too much artificial light; not enough natural light; it was too noisy with little control over noise and there was an overall there was a very high dissatisfaction level with overall comfort rated at 71per cent dissatisfied and perceived productivity was scored at -13per cent.

Figure 4: After redevelopment, there was huge improvement in occupants' response to the building. It scored particularly well in terms of 'design', 'needs' and 'image'. Perceived productivity was scored at minus one per cent which, although an average result, represents a step change improvement (49 per cent) from the original. In terms of summary index, Elizabeth II Court (East) scored in the top 40 per cent of the UK benchmark dataset, which is a vast improvement (59 per cent) compared with the original low base. The perceived score could well have been higher had there not been a difficult 18 months of initial occupation while the remainder of the Ashburton Court buildings were being completed.

Control of ventilation is generally good both in summer and in winter, although a balance needs to be struck between indoor air quality, occupant comfort and heating energy consumption.

Apart from maintaining window closed during weekends when night cooling is possible, the automatic windows were generally operating as intended: fully open during warmer spells, modulating during cooler periods, and closed when the external temperature is below 15°C.

Although perceived productivity is scored as average, it represents a step change improvement over the original building. Overall, The East block scores in the top 40 per cent of the UK benchmark dataset, a vast improvement compared with the original building.

Performance might have been even better had there not been a difficult 18 months of initial occupation as the other blocks of Elizabeth II Court were being completed.

What this tells us

The east block of Elizabeth II Court was a classic opportunity for demonstrating low carbon refurbishment. It had a committed client and suitably experienced and enthusiastic design team. The frame of the original building was ideal for maximising opportunities for natural ventilation and daylighting. It achieved a BREEAM excellent rating and has since won a number of construction awards.

For occupants, the East block is performing particularly well in terms of design, needs and image – all issues highlighted in the brief. This is a reasonably good result, but not top of its class, which is a little surprising. It may be the result of initial problems associated with the phased construction. Some of the more specific issues highlighted included control over lighting, heating, ventilation, cooling and noise as well as temperature and draughts.

Temperature control has been generally effective both in winter and summer, although there is some scope for optimising night cooling. Control of ventilation using the carbon dioxide level as an indicator has been generally effective, both in both summer and winter.

However, teething problems with the carbon dioxide sensors caused draughts. "We found that the CO_2 sensors were the controlling sensors in the winter, so we got to a point where the chimneys opened and cool air was dumping on people sitting close to them," said Steve Hall. "We raised the carbon dioxide setpoint slightly, and that seemed to resolve the issues without any problems of 'stuffiness'"

The automatic windows have operated well, although Steve Hall has noticed that early morning sun tends to penetrate deep into the building, causing occupants to drop blinds because of glare. Many don't lift them back up later, which leads to blinds down and lights on.

The data centre heat reclaim system appears to be meeting the mechanical ventilation heat demand in all but the coldest month.

The facilities contractor, Emcor, reported that the building works well from an operational perspective but is quite complex. Dealing with staff complaints is therefore more of an issue. The response to complaints about lighting and control tends to be reactive and therefore rather ad-hoc.

The most challenging day is one that is warm and windy, as some staff complain about draughts and feeling cold. Internal blinds also flutter in the wind. Every floor tends to be different but the higher up the building the windier it gets. Hot, still days tend to be better. The spring and autumn are the trickiest.

Steve Hall says that in the three years since the building was occupied, occupant numbers have increased to 270–280 persons, up from the design density of 250. "We found we were conservative in the way we thought the building would be used. We are able to work it harder," he said.

Overall, the performance of the East block of Elizabeth II Court represents a huge improvement compared with the original building, in terms of energy consumption, carbon dioxide emissions, and occupant satisfaction. The HCC says it is already fine-tuning the building to optimise energy use.

This article is based on building analysis carried out by Alan Jefcoat and Harriet Boyce of Arup. The design, construction and post-occupancy performance of Elizabeth 2 Court (East) was studied by the Carbon Trust under its Low Carbon Building Accelerator (LCBA) initiative. The LCBA aimed to accelerate the take-up of cost-effective, low-carbon initiatives of non-residential building refurbishment projects by gathering data and demonstrating effective energy-efficient solutions. LCBA case studies track projects from original use, through design and construction to post occupancy.

Roderic Bunn EngD is a principal consultant in building performance analysis at BSRIA, working for the Carbon Trust on its Low Carbon Buildings Performance programme. He manages the Soft Landings initiative at BSRIA and is a Building Performance Evaluator for the Technology Strategy Board.

Key lessons

Maintenance and management

Operation and maintenance manuals were available in draft hard copy format but it took some time to finalise them and issue electronically. Demonstration of some systems such as the VRV system central supervisor and the Autometers power management system occurred later and was less thorough than it could have been. Through necessity the BMS central supervisor was initially located in a store until it was moved to its final location in the once the second phase of development was complete. This did not help to stimulate use and ownership from the outset.

Energy metering

A building logbook uses the CIBSE 2003 template, but crucially, there is no content on the metering monitoring and targeting strategy. After occupation, HCC found that some meters were not recording data accurately, particularly where submeters were installed in series. Some systems had five to six sub-meters in series, and HCC found 2 per cent errors in each one, causing the last one to be out by up to 10 per cent. Tracking down the errors and understanding the gaps involved time-consuming detective work. Ideally, all metering should be fully checked and calibrated as a vital part of the preparation for monitoring after handover.

Occupant issues

After moving into the East block, Hampshire County Council appointed a number of office champions. However, it was difficult to engage these champions in building services issues. While a 30-page building user guide was written, only one page was devoted to building services. Arguably, such user guides should not attempt to cover the description and operational requirements of building systems alongside management issues, such as catering, fire evacuation procedures and the use of office equipment. Separate guides could be produced, or a single guide split into two distinct sections. A more detailed description of the building services systems was prepared by the building services consultant but was not formally issued to staff as HCC wanted to avoid information overload at a time when staff were moving into a new building and still having to do their day job.

System usability

There were some examples of a lack of understanding by staff of how to use radiator thermostatic valves. This led to thermostatic radiator valves being set high with manually opening windows above them slightly open. There was also repeated evidence of poor adjustment of VRV room unit temperature set points, both when heating and cooling. The user notices above VRV room controllers provided incorrect directions to staff and were neither clear nor concise. Many of the user notices above the ventilation override controls at each core on each floor had been removed. HCC addressed this with better information on how the systems operate.