Probe Strategic Review 1999

Report 5: Building Descriptions

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Preamble

This serves as supplementary material to the foregoing four Probe Strategic Review papers. It has descriptions of each of the sixteen buildings, with material which complements the findings introduced earlier (that is, with an emphasis on technical, energy and occupancy aspects).

The table below gives names and acronyms used, plus sequence numbers.

Buildings are introduced in the order of;

1. offices;
2. educational buildings;
3. other types

so that the text reads without unnecessary repetition.

Illustrations and photographs are drawn from field research material. Photographs of higher quality may be found in the original *Building Services Journal* articles.

Probe 1 Buildings investigated

Sequ #	Full name	Location	Site	Short name	3-letter	Type	Gp	HVAC	Article	#
1	Tanfield House	Edinburgh	IC	Tanfield	TAN	Large administrative centre	O	AC/(MM)	Sep-95	1
2	1 Aldermanbury Square	London	CC	Aldermanbury	ALD	UK Head office (speculative)	O	AC	Dec-95	2
3	Cheltenham & Gloucester	Gloucester	BP	C&G	C&G	Large head office	O	AC	Feb-96	3
4	de Montfort Queens Building	Leicester	IC	de Montfort	DMQ	University teaching	E	ANV	Apr-96	4
5	Cable & Wireless	Coventry	BP	C&W	C&W	Company training college	M	ANV/NV	Jun-96	5
6	Woodhouse Medical Centre	Sheffield	IC	Woodhouse	WMC	Medical surgeries	M	NV/(MM)	Aug-96	6
7	HFS Gardner House	Harrogate	BP	HFS	HFS	Principal office	O	AC	Oct-96	7
8	APU Queens Building	Chelmsford	IC	APU	APU	Learning Resources Centre	E	ANV	Dec-96	8
Probe 2 Buildings investigated										
9	John Cabot CTC	Bristol	IC	Cabot	CAB	Secondary education	E	NV/ANV	Oct-97	11
10	Rotherham Magistrates Courts	Rotherham	IC	RMC	RMC	Courtrooms and offices	M	MM	Dec-97	12
11	Charities Aid Foundation	West Malling Kent	BP	CAF	CAF	Principal office (per-let)	O	MM	Feb-98	13
12	Elizabeth Fry Building	Norwich	UC	Elizabeth Fry	FRY	University teaching	E	MM	Apr-98	14
13	Marston Books Office	Abingdon	BP	MB Office	MBO	Principal office (per-let)	O	NV/(ANV)	Aug-98	16
14	Marston Books Warehouse	Abingdon	BP	MB Warehouse	MBW	Warehouse (pre-let)	M	NV	Aug-98	16
15	Co-operative Retail Services	Rochdale	BP	CRS	CRS	Large head office	O	AC/(MM)	Oct-98	17
16	The Portland Building	Portsmouth	IC	Portland	POR	University teaching	E	ANV/MM	Jan-99	18

Site: BP=Business Park or similar; CC=City Centre; IC=Inner City; UC=University campus
Group: E=Educational; M=Miscellaneous; O=Office

HVAC: AC=Air Conditioned; NV=Naturally Ventilated; ANV= Advanced NV; MM=Mixed Mode (Bracketed if minor influence)

Tanfield House (TAN, Probe #1)

The 24,000 m[2] (gross, not including the underground car park) administrative headquarters of Standard Life was the first Probe and the largest building studied to date. Completed in 1990, this owner-occupied groundscraper on the edge of Edinburgh New Town houses 1300 largely clerical staff. It has two very deep open-plan floors, up to 120 m across, punctured by three atria. The office floors have underfloor VAV air conditioning, uplighting, and tall (3.6 m) exposed concrete ceilings with no services other than sprinklers.

The twin-walled facade is of an irregular shape with outer fixed glazing, a ventilated walk-though interspace, and inner sash windows which can be opened manually, or dropped automatically in a fire. Lengths of fully-glazed curtain walling span between stone stair/service towers which give a sense of solidity and help to unite the building with the Edinburgh New Town vernacular and the retained facade of the former Woolstore at the NE corner. Below the two office floors are two levels of car parking for a total of 306 cars (24% of staff).

> *Variable air volume.* Air is introduced into a zone at constant temperature (at Tanfield with slight variations between seasons) and in quantities which increase with the cooling requirement.

Surveys in the 1980s suggested that very deep, open-plan air-conditioned building with largely clerical occupancy had all the danger signals for high levels of building-related sickness symptoms. However, initial impressions were good and the occupant survey revealed that TAN performed well. Why? Essentially the answer was:

- A committed and experienced client representative throughout the project, and who then became responsible for managing the building.
- Good procurement, by a traditional route over a seven-year period of site assembly, needs assessment, briefing, design, review and ultimately construction.
- Good, imaginative, careful design.
- Excellent, responsive facilities and engineering management, applying the firm's policy of customer service and continuous improvement to their own customers, the occupants.

Energy consumption, however, was high - even for a prestige air-conditioned office. Some of this resulted from the high occupancy and equipment levels, but much was also related to systems being too powerful (at least in hindsight) and/or on too much owing to control problems.

For example, for lighting:

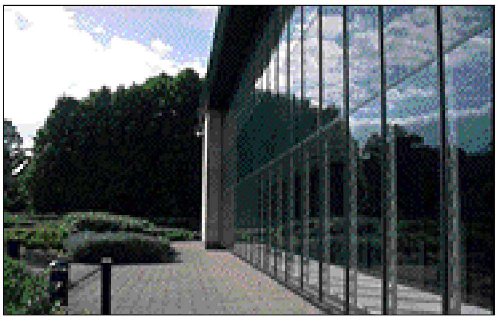
- All the circulation and toilet lighting came on together whenever the building was occupied.
- The meeting rooms were also initially on these circuits, but were given independent switches when it proved impossible to show slides! Surprisingly, this oversight is not uncommon.
- The extended restrike times of the high-intensity discharge uplighting meant that it could not be turned off if there was a chance it would be needed again. In any event, individual occupants could only select high/low.
- The large open-plan nature of the spaces - together with cleaning right through the night by a small and effective team - meant that the office lighting tended to default to ON.

Such over-usage problems proved to be widespread in Probe, particularly in the more highly-serviced buildings. Following their continuous improvement philosophy, the results of Probe caused the FM team to increase their responsiveness to occupant comments still further, and to accelerate the implementation of the energy-saving measures identified; in particular replacing the eddy-current drives for the main VAV fans with more energy-efficient inverter drives.

The long gestation time of TAN and the bespoke solution which emerged for an established owner-occupier are unlikely to be repeated for many office buildings in the UK today. TAN was built by a firm with a long history in Edinburgh, and which planned to occupy its new building indefinitely - as it most probably will.

However, in the fifteen years since the need for TAN was identified, the world has changed. Markets are changing fast and even the most well-established company may find itself facing competitive threats; mergers and acquisitions; and periods of rapid change with the need to move quickly. They are therefore forced into the rental market, or at least to build offices which are more subdivisible and closer to established market standards, so that they can be valued and traded. Standard Life's recently-completed new head office in Edinburgh is of this kind, and was a pre-let in collaboration with a developer.

Tanfield House (TAN, Probe #1)



1 Aldermanbury Square (ALD Probe #2)

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ALD, a seven-storey (plus two basements) 8,000 m^2 A/C office in the City of London was the only truly speculative building in the whole Probe data set (CAF and Marston Books were pre-lets). The rectangular building occupies a corner site, and was the only Probe building not free-standing - one flank wall and part of the back wall adjoin other buildings. It was nearly two years between its completion and its occupancy by a single tenant (Standard Chartered Bank), in which some continuity was lost, so understanding and design and record information was not nearly as good as first encountered at TAN.

ALD's A/C boasted a number of relatively novel features, particularly for a speculative building:

- An ice storage system.
- Low temperature air distribution.
- Fan-assisted variable-volume and temperature (VVT) units to blend the low-temperature primary air with room air.
- Local optimising controls for the VVT control zones plus more conventional central controls for the boiler, chiller and ice storage equipment, but no BMS.

> *Ice Storage* The chiller makes ice, usually overnight, which is then melted the next day to provide cooling, either instead of or as well as the chiller. This both permits use of - often much cheaper - night time electricity (usually between midnight and 7 AM) and also provides additional cooling capacity to meet peak daytime demands.

Low temperature air can potentially save energy by reducing the fan power required for air handling. On the other hand, the refrigeration will be less efficient (see below) and more humidification may be required. Ice storage tends to increase energy use: chillers become less efficient at the lower temperature and heat has to be double-handled in and out of the store. There are also additional standing losses from the extra surface areas of the pipes and storage vessels; the larger temperature differentials; and some condensation at ALD. However, there can be savings in fuel cost (night electricity can be much cheaper), and possibly carbon dioxide (since a higher proportion of baseload electricity is generated by renewable, nuclear and the more efficient fossil-fuelled stations). At ALD there were also some important site-specific reasons:

- The ice storage reduced peak electricity demands: at the time of design, over-estimated electrical requirements for office equipment and air-conditioning had been causing fears of electricity shortages and demand restrictions in the City.
- Ice storage also reduced the space required for chillers and heat rejection equipment on this restricted site.
- The low-temperature air permitted air volumes and duct sizes to be smaller, which here allowed ALD to have an additional floor within the planners' prescribed sight lines; but at some cost in increased fan power.

Probe however indicated that ALD's energy consumption was relatively high owing particularly to fans at high pressure, pumps transferring chilled water in and out of store, and reduced chiller efficiency when making ice. In addition, with the electricity supply contract applicable, the off-peak chiller use for ice making did not translate into lower overall bills. The contracts available which offered cheaper electricity at night also charged more for it during the day; and the overall balance of ALD's consumption profile produced no savings.

When considering potential benefits of night electricity use, it is necessary to consider the load profile of the building as a whole - and not just the off-peak system - in relation to the contracts available. However, such information is subject to changing commercial factors, and may not be known to the designers. ALD's energy costs could probably have been lower (and occupant satisfaction higher) if the occupier had devoted more time to fine-tuning the system. The occupier agreed, but said that the building was more demanding than they were accustomed to, and they had achieved what they thought was the most appropriate balance between effort, cost, performance and occupant satisfaction.

This study illustrated some recurring points in Probe about design for manageability, particularly in speculative buildings where a tenant (or a contractor) will tend to be less likely than an owner-occupier to buy into an unfamiliar concept. Having said that, some later Probes indicate that it is one thing to be prepared to pay for energy-saving features and quite another to be prepared to devote the necessary effort to looking after them. Although there is scope for better management, "keep it simple and do it well" is a strong message.

Cheltenham and Gloucester (C&G, Probe #3)

C&G was Probe's first out-of-town office, on a suburban site set back from a roundabout at Barnwood, on Gloucester's by-pass road. As commonly happens, the move to this type of office increased the staff's car use. In the Probe survey, 89% of staff travelled to work in their own car. None in the sample shared cars - the others either walked or used a bus. Average journey-to-work mileage had increased from 15 to 19; but 45% had a journey of less than 5 miles, which potentially might be cycled. Since the number of staff in the building had also risen to 930 from an intended 700, the original 450 car parking spaces were not enough and were increased to 600 (65% of staff): these were also under pressure and unfortunates sometimes had to park nearby.

The estimated car fuel consumption for commuting was 324 kWh/m^2 of building area per year: 2.5 times the building's normalised gas consumption]. However, the extra car use stimulated by out-of-town location does not stop there: once the car habit is reinforced by commuting requirements - perhaps requiring the purchase of a first or second car - studies indicate that cars become used more for other purposes too.

At 20,000 m^2 and also completed in 1990, C&G was almost as large as TAN, and for a similar financial services organisation. However, it had many significant differences, including :

- A head office, with a more diverse range of functions, more cellular offices, lower occupancy densities, and a computer suite (Standard Life's main computers were not in TAN, but a dedicated building nearby).
- Owing to rapid organisational growth and change, the building had been required urgently and was briefed and built rapidly, taking only two years from decision to occupation.
- Perhaps for this reason, it had no basement and was a simple rectangular shape around a central atrium, and divided into four similar quadrants as far as plant was concerned.
- Systems were relatively conventional for the time, for example VAV A/C from the ceiling.

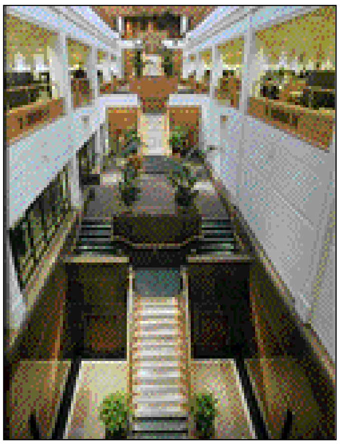
In spite of the speed, standardisation and relative conventionality, the building is of high quality. The occupants however regretted the lack of storage space, which might have been available in the basement of a less rapidly-constructed building; and off-site storage had to be obtained. In places more time might have allowed the building's planning to be improved, for example in the relationship between entrance and atrium and the space planning on the top floor; where the two occupied ends are separated by plant and long corridors.

C&G's urgent requirement also coincided with an overheated building industry at the time of construction and completion. C&G's management felt that the building had been completed in too much of a hurry and then rapidly abandoned by the building team. They thought this had, for example, led to problems with airtightness - but sadly this was not unusual in Probe, nor indeed in recent UK buildings generally - as work by BRE, BSRIA and others has shown. Widespread problems with solar gains and glare had resulted from a client decision not to install the external shading the designers had recommended: they had felt that it would mar the building's clean appearance. Hence the translucent curtains had had to be doubled-up and were often kept shut.

Its relatively conventional services would generally have been regarded as less energy-efficient than those in the other four Probe A/C offices. In fact, C&G was the lowest-energy user, though for most end-uses still above the ECON 19 Good Practice benchmark for a "Type 4" prestige head office. It had some nice touches, including differently-coloured light switches for lobby, circulation and office space and a common glycol heat rejection and free cooling system for the water-cooled 700 m2 computer suite. The Probe team had some doubts whether the free cooling was saving much energy in practice - but this would have required a more detailed study over a longer period. Apart from FRY, C&G was the only Probe building to be seriously practising energy management at the time of the Probe survey. Even here, the energy manger said that the potential had been restricted by general management - who were not prepared to support measures which might carry any risk to service, comfort and reliability in their chief office. This is a common message from UK offices in the 1990s.

Glycol cooling: The refrigeration compressors in the room units at reject their heat into a cooling water which is then pumped through air-blast coolers (like large car radiators) on the roof. In chilly weather (typically below about 8°C) the return water can cool the computer room directly. It is therefore passed through cooling coils in the room air conditioning units first, to reduce or eliminate the use of the compressors. The name "glycol cooling" is used because ethylene glycol has to be added to the circulating water to stop it freezing in cold weather.

Cheltenham and Gloucester (C&G, Probe #3)



HFS Gardner House (HFS, Probe #7)

HFS Gardner House (HFS, Probe #7)

Gardner House, Harrogate is the headquarters of Homeowners Friendly Society (HFS) and was the smallest (4,100 m^2) of the A/C offices in Probe. It was the result of an architectural competition for a rural site just outside the city and at the far edge of a former industrial complex (now a business park) with a railway station on the opposite edge, about ten minutes' walk away. The site has a spectacular outlook to the south into the Crimple Valley and its Victorian railway viaduct.

In spite of the open site, the building is air-conditioned. HFS's former premises in central Harrogate had suffered high temperatures and poor air quality owing to poor environmental design of this early post-war building, plus overcrowding as the company grew rapidly in the late 1980s. HFS therefore wanted to do their best for their staff, and were also advised that a building with A/C would be more marketable if they ever wanted to move on or to sublet. They had already been impressed by buildings with static cooling, and finally chose a system with displacement ventilation, chilled beams and 100% fresh air.

The three-storey building is cut into the hillside and is square, with two stubby wings at the SE and SW corners. Its architecture juxtaposes heavy stone elements for the ground floor, gable ends etc.; with inserts of lightweight curtain walling under a pitched slate roof. The principal open office floor has some 1500 m^2 of open plan area and a suite of meeting rooms and cellular offices on the south side. Above it is a square doughnut of management offices facing outwards with an internal glazed corridor around a central courtyard. Below this is a lower ground floor on the east side only, with offices facing onto a lawn to the east and storage and plant rooms behind them against a retaining wall to the west.

> *Displacement ventilation* introduces air slightly below room temperature at floor level in a controlled manner, often from under the floor (although large-area wall diffusers or free-standing turrets can also be used). The air then rises over occupants and equipment and is extracted at high level. Advantages claimed are simpler control (within design limits, the occupied zone stays at a similar temperature whatever the cooling load) lower cooling demands (because the rising warm air is extracted directly) and higher air quality, because the pollution rises with it, and is mixed less with air in the breathing zone.

In spite of the care taken in seeking a good building, HFS were unhappy about site management in the later stages of construction, when the original manager left and a promised M&E coordinator never appeared. They therefore felt that the building was not properly finished when they moved in; and then found difficulties in achieving the anticipated comfort levels. An important reason for this proved - yet again - to be a lack of airtightness: at the eaves, at the junctions between the curtain walling and the windows with the stonework, and through the mullions and transoms of the curtain walling system itself. At the time of the Probe survey, remedial measures had been taken but with less than 10% improvement in the pressure test results. Comfort was particularly affected because the air turnover rate of 3 ac/h was relatively low for an air-conditioning system, so there was less power to spare than for the VAV systems in the previous three buildings. Consequently, the A/C plant had to be run for extended hours, increasing its energy use and running costs, and still leading to occupant comfort levels little better than average at the time of the occupant survey.

HFS's lighting also made widespread use of luminaires with automatic occupancy-sensing and dimming. Unfortunately the anticipated energy-savings had not materialised and lighting energy consumption was slightly above Typical levels. There were four main reasons for this:

- A relatively high design illuminance level of 600 lux in the offices, contributing to an installed power density (IPD) (18 W/m2) 50% higher than the ECON 19 good practice level of 12.
- Difficulties in commissioning the controls satisfactorily, owing, for example, to upward reflection of daylight from the slats of the venetian blind onto the photocells, requiring settings to be increased.
- Automatic switching-on of lights to achieve the 600 lux or more, even when the occupant regarded the daylight as adequate; leading to excessive use - particularly in the cellular offices.
- Occupant disturbance by lights triggering in the open plan area, leading to all lights being switched on and left on for all the core time.
- Little effective control of lights in circulation areas, which tended to be left on all day.

Charities Aid Foundation (CAF, Probe #13)

CAF - at Kings Hill Business Park on the former West Malling aerodrome near Tonbridge, Kent -was the first office building in Probe 2. It had several other Probe firsts:

- Pre-let: constructed by the site developer (Rouse Kent: a partnership between Rouse - a commercial developer - and Kent County Council) for letting to CAF.
- Construction under a management contract, not a traditional one, with a clear focus on speed and buildability. The work was split into 35 self-contained subcontract packages, tendered separately; and including items such as packaged and largely pre-commissioned ventilation plant and a prefabricated boiler plant room, craned onto the roof. This process allowed (for example) work to start on the frame before decisions had been made about other aspects of the design; and for the designer to concentrate on resolving design details and interfaces with the trade contractors while the manager did the administration.
- The first truly mixed-mode office building in Probe: a concurrent design with full fresh-air mechanical ventilation from the floor and top-hung projecting openable windows, with similar but smaller openable fanlights above. TAN had MM aspirations (the lower sashes of its windows were openable), but these had little real meaning or utility (except perhaps in an emergency) in such a deep office. Indeed, following practical experience, the use of TAN's windows was discouraged by its management.
- Ventilation plant with indirect adiabatic cooling.
- Telephone-controlled lighting in the office areas. Unfortunately this was performing less well than had been hoped owing to zoning too coarse for individual control, an unwieldy PIN number system, and no local light switches for visitors and cleaners.

The 3-storey U-shaped building has exposed concrete ceilings to help stabilise internal temperatures. These were elegantly modelled with slots for partitions and shallow dished coffers surrounding light fittings (some with air extract points), but no acoustic treatment, which added to occupant perceptions of the building being noisy. On the top floor, the concrete ceilings had insulation on top and a shallow-pitched metal roof over much of their area to protect high level ductwork and electrical services to the second floor offices. CAF were keen on daylight, so the architect added rooflights to two wings of the top floor, with punched holes in the roofslab, in place of some of the coffers.

In practice, however, solar gain and glare was a problem; and in 1998 blinds were under investigation. Motorised blinds had also been retrofitted to the double-height planar-glazed wall of the SW-facing reception area. In common with many buildings, the windows did not provide optimal control of ventilation, closing themselves too easily either by gravity or with a puff of wind; and with the fanlight handles not easy to reach, particularly when open. Higher levels of occupant satisfaction and energy performance had been found in pre-let buildings than in either owner-occupied or speculative ones. Although possibly a quirk of a small sample, a possible reason was that owner-occupiers could be self-indulgent in their requirements and - if not procuring buildings regularly - might also lack the experience as a client to ask questions and exercise effective control. Conversely, developers might not understand certain occupier needs; and be unable to fund features which - however good - were not reflected in market valuations and rental levels. Putting the two parties together might achieve better user value within the discipline of the market.

However, at CAF occupant responses were no better than average, perhaps because here the landlord (via maintenance contractors) looked after the fabric and ran the services (CAF had no access to the plant room or to the system controls), while the pre-let buildings studied before had strong in-house technical management with full responsibility for running them. The landlord/tenant split also complicated the Probe study: the landlords were helpful on the first visit, but not prepared to give any more of their or their maintenance contractor's time after that. At 3,900 m^2, CAF is a similar size to HFS, and on a similar parkland site. Both organisations outgrew their former town centre accommodation at much the same time. Although different in origins, both now undertake similar work, providing advice and financial services to individuals and organisations. This permits an interesting comparison between the MM and A/C approaches to these two buildings. Although neither is a particularly efficient example of its type (and both have airtightness problems), CAF's energy consumption was less than half HFS's.

The *installed power density* (IPD) of a service, in Watts per square metre, is the total electrical load in the area concerned, divided by the floor area. It can be a useful guide, and can be applied to end-uses other than lighting. For instance the electrical demands (and heat output from office equipment is usually stated this way.

Charities Aid Foundation (CAF, Probe #13)

Marston Book Services Office and Marston Books Warehouse (MBO and MBW, Probe #16)

Marston Book Services Office (MBO, Probe #16)

The 1,000 m² MBO is a relatively shallow-plan (13.5 m glass-to-glass) brick-clad building with a metal pitched roof. Largely open-plan, with a few cellular offices, it was the smallest office studied in Probe and the only naturally-ventilated (NV) one. It was also a pre-let to a tight budget, procured by a construction management route as part of a larger development with the attached warehouse MBW (outlined later).

The office aimed to provide good comfort with low energy use and includes some advanced (ANV) features: motorised rooflights and fanlights (though with manual local and central control only) and ventilation grilles in the suspended ceiling on the ground floor to improve access of the air to the floorslab mass. In previous projects, the site developers had had difficulty in procuring suitable windows for naturally-ventilated low-energy buildings rapidly and reliably. They were looking for a kit system which could receive - as required - items such as operating motors, acoustic shields, and light shelves; and with sufficient mechanical strength in the transom below the fanlights to support projecting external sun louvres. Requirements and solutions were first developed in the Lansdown Window System study. The ideas were subsequently engineered and marketed by Colt as the Interactive Window System, of which Marston Books was the first full-scale application.

The design also aimed for good use of daylight, using window design, rooflights, tiltable lightweight light shelves, and automatic lighting controls. Sadly - but again as in many buildings - the results were disappointing, owing to problems with glare control at the windows and the functionality, usability and occupant acceptance of the lighting control system.

MBO and the much larger MBW (five times the floor area, fifteen times the volume) shared the same electricity and gas meters. Although the average energy consumption was low, it was difficult to resolve the contribution of the office to this. In addition, the availability of meter readings from the gas bills was abysmal - with nearly all the bills estimated (again as in many Probes) so it was impossible to discern degree-day variations.

Following a request from the Probe team, office submeters were kindly installed by the developer. These revealed that the office's energy performance was reasonable, but only a little below ECON 19's "typical" benchmark for a "Type 2" open-plan naturally-ventilated office. Reasons included a relatively high use of artificial lighting; disappointing air infiltration levels; and a surprisingly high heat requirement by the toilet supply ventilation unit - which also meant that the boiler had to be on nearly all the year, incurring standing losses. Heat recovery or extract-only ventilation would have been considerably more economical.

Light shelves are designed to reflect incoming skylight from upper window elements onto light-coloured ceilings to improve daylight uniformity. The APU light shelves are made from semi-mirrored but transparent glass and reflect light onto a white painted coffered slab ceiling.

Co-operative Retail Services (CRS, Probe #17)

CRS's 18,400 m^2 5-storey building outside Rochdale was the only AC office in Probe 2, and although for a retail organisation was similar in many ways to Probe 1's TAN and particularly C&G. In addition to some 8,000 m^2 nett of largely open-plan office area arranged around a series of atria, it included other facilities such as large restaurant with separate (and unusually and commendably separately-metered) services. Like HFS, the building was cut into a hillside. It has a large (1,300 m^2) suite of computer rooms in the internal areas, cooled by close-control down-blow room units connected to a central chilled water system with glycol free cooling. Some of the computer rooms were under-occupied and unusually (but creditably) the reserve AC units - about one-third of the total - had been switched off. Nevertheless - and as often happens - estimated energy use for the computer suite AC was higher than that of the equipment in the rooms.

Like HFS, CRS has chilled beams and displacement ventilation. Like TAN, it has HID uplighting (and control problems leading to over-use), an exposed ceiling (here with a sprayed acoustic finish), and air exhaust through the atria. Unlike C&G and TAN, it did not have its own on-site engineering staff. Instead this work was outsourced to a maintenance contractor who had an on-site supervisor and staff. Like nearly all the buildings in Probe, there was little or no energy management - exceptions in the offices were C&G and FRY (see below) - but CRS was beginning to become interested in the potential.

As on many sites where contractors are employed, contract conditions often do not have explicit requirements for plant operation and energy efficiency, which therefore fall through the gap. One consequence at CRS is that the systems did not seem to be working optimally. For example:

- There seemed to be a lack of cooling capacity, but the chillers were not working hard.
- Humidification seemed to be being over-used (a common problem in Probe, and in other humidified offices visited by team members).
- Plant was running to the original time schedule, even though the office got hot overnight (owing to the high insulation levels and direct and stored heat gains from office equipment and lighting). An earlier start or some overnight running could well have improved matters.

Like ALD, CRS's office air conditioning included ice storage. Also like ALD, the system had created difficulties for the occupier: here from low reliability owing to repeated bursting of the plastic pipes which transfer heat between the circulating glycol and the ice; each time also losing the whole glycol charge. The reason for the bursts was not entirely clear: maintenance thought that they could well have arisen from limited headroom over the tanks, causing the last batteries of pipes inserted into a congested tank to be kinked and scratched in the process. With the chillers at roof level and the tanks in the basement, the pressures involved may also have exploited any points of weaknesses.

CRS was unusually well insulated (though the walls and floors at FRY were better). Gas consumption, although lower than the ECON 19 Typical benchmark for a head office and at ALD, HFS and TAN, was higher than the older and less well-insulated C&G. Reasons included:

- The need to preheat air in a displacement ventilation system, even often in summer.
- Air infiltration: while measured leakage at CRS was at a normal UK level, it was over three times BSRIA's recommended standard for an air-conditioned building.
- Energy management at C&G, which for example had installed a small summer boiler for kitchen hot water in summer and turned its main boilers off.

Like C&G and CAF, CRS's move out of town had increased car use and taxed the car parking capacity initially regarded as adequate. The surrounding roads were congested with the overflow of CRS's parked cars.

Static cooling has no moving parts in the spaces cooled, for example using embedded coils in the fabric of the building, cooled radiant panels (e.g. chilled ceilings), or natural convection to extract heat. So-called chilled beams consist of finned pipes fixed to the ceiling in a boxed enclosure to assist the natural convective flow and improve appearance. These linear boxes projecting down from the ceiling look a bit like downstand beams, hence their name. The chilled beams at HFS are partially recessed into a suspended ceiling. Those at CRS are fixed directly to an exposed soffit.

Co-operative Retail Services (CRS, Probe #17)

Offices in the Elizabeth Fry Building (FRY, Probe #14)

Although part of an educational building, the offices at FRY make an interesting comparison with the buildings above. A well-insulated and airtight envelope permitted perimeter heating to be dispensed with, save in four offices in exposed corner positions, which required additional electric panel heaters - each with a low rating of 200 Watts. Nearly all heating and cooling in this mixed-mode building was provided through mechanically-ventilated hollow core floor/ceiling slabs with heating, free cooling and highly-efficient regenerative heat recovery.

Occupants can open windows in this concurrent mixed-mode design, but - and as intended - windows are little used because the mechanical system maintains cool, fresh conditions in summer, as confirmed by the occupant survey; though occupants would also have welcomed more options for window adjustment. In spite of the energy used by the mechanical ventilation, the services in this building used less energy than any other Probe offices, even the naturally-ventilated MBO. However, with a cellular office plan and lower hours of use, this is not an entirely fair comparison; which is why the ECON 19 benchmark for naturally-ventilated cellular offices is lower than for open-plan ones. After fine-tuning, FRY's CO_2 emissions were close to the Good Practice benchmark for naturally-ventilated cellular offices..

De Montfort Queen's Building (DMQ Probe #4)

DMQ has academic facilities for about 100 staff and 1,500 students in the School of Engineering and Manufacture at de Montfort University, Leicester. Occupied in 1993, it is of particular interest for its daylighting strategy and its innovative use of natural ventilation, with its distinctive ventilation stacks. It also has a small CHP unit. The 9,850 m^2 (gross) building has three distinct areas: the central building, the mechanical laboratories and the electrical laboratories. A full height concourse in the central building acts as lightwell and thermal buffer zone for adjoining spaces, including ground floor main auditoria and classrooms ventilated by the stacks. The mechanical laboratories are mainly a naturally-ventilated machine hall, flanked by small specialised mechanically-ventilated labs which also form an acoustic buffer. The electrical laboratories are housed in two shallow plan, four storey wings either side of a narrow courtyard which facilitates simple cross ventilation and well-distributed daylighting; though with somewhat unusually placed windows.

The design team's concept for DMQ was a highly insulated (e.g. wall U-value is 0.3 W/m^2 K), thermally massive envelope with generous ceiling heights (3 to 3.3 m) to facilitate natural ventilation and daylighting; and greater heights in main circulation and the mechanical laboratories. The ANV building uses innovative ventilation stacks and passive design features for summer comfort. Control of internal conditions relies extensively upon a BMS to control roof vents and motorised dampers. The complexity of the passive control requirements led to the use of BMS algorithms written in plain English, which could also support student usage. The client and the design team knew that extended monitoring and fine tuning would be necessary over the first year in relation to changing internal and ambient conditions. Unfortunately, however, various problems and disputes during the defects liability period made intervention difficult and meant that the system was not fully commissioned, even by the time of the Probe survey. This led to some initial occupant dissatisfaction, particularly with comfort on the third floor due to non-functioning rooflight opening mechanisms (since resolved) and uncontrolled heating circulation.

BRECSU commissioned extensive monitoring of this innovative building, particularly of the auditoria with their 13 m high stacks. The results confirmed the outcome of short-term heat load tests, as recorded air temperatures tended to remain stable between 20 and 22°C. In winter there were some initial problems with thermosyphoning in the stacks, now reportedly resolved. The stacks, although highly distinctive, are questionable from the point of view of cost-effectiveness and maintenance. Although potentially the quest to avoid fans is praiseworthy, potentially low-powered extract fans at high level could have done a similar job using very little electricity.

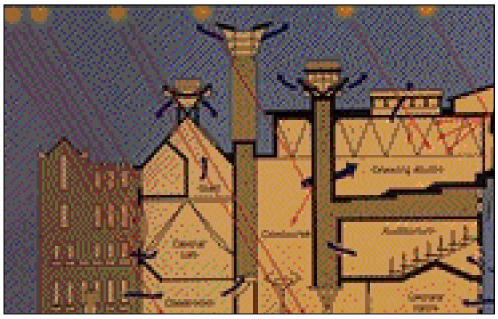
Probe distinguishes between natural ventilation (NV) with openable windows for single-sided or cross-ventilation as in traditional buildings; and the more highly-engineered advanced natural ventilation (ANV), using techniques such as openings other than windows, natural buoyancy effects through stacks and atria. ANV is often combined with motorised and automated controls, and designed with the benefit of computer simulation.

In energy terms, DMQ performed well with overall CO2 emissions nearly 30 % below EEO low figures. However, heating and lighting energy consumption were relatively high in relation to other Probe educational buildings. A lead condensing gas boiler meets nearly half the annual heating requirement. The CHP unit provides about 15% of heat demand and runs for about 60% of boiler run hours - the expected kitchen HWS base load never materialised.

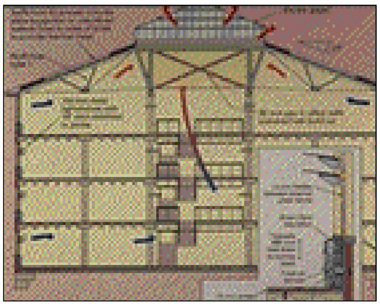
On the occupancy side, staff strongly disliked the move to open plan accommodation, which was on the top (third) floor of the building, where their dissatisfaction was compounded by high temperatures. Historic BMS data shows high average temperatures in third floor staff areas, with daily summer peaks reaching 30°C (the outside temperature peaked at 32°C). However, the systems were not working properly. The remainder of the building reportedly maintained satisfactory internal conditions even during the heatwave in the summer before the Probe survey.

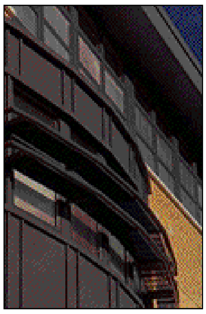
CHP (Combined Heat and Power) uses an on-site engine (usually gas-fired) to drive an electrical generator, while the engine's waste heat is recovered and used for heating, sometimes hot water, and occasionally absorption chilling. Overall conversion efficiencies are high, but economic use depends on the availability of a year-round heating demand which is rarelyfound. To meet normal economic criteria, useful heat typically needs to be required at the full capacity of the CHP unit for 4,000 hours a year or more; and preferably between 7 AM and midnight.

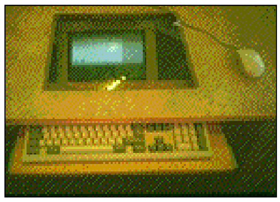
De Montfort Queen's Building (DMQ Probe #4)

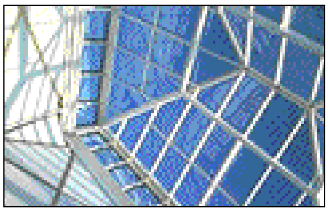


Anglia Polytechnic University Queen's Building (APU, Probe #8)









Anglia Polytechnic University Queen's Building (APU, Probe #8)

Anglia Polytechnic University obtained university status in 1992 and needed to consolidate its activities in Chelmsford on a single site. It acquired a 9 hectare former industrial site in central Chelmsford. The Queen's Building, occupied in August 1994, was its first building there; and a flagship building for the University. Its mix of library, IT and café-bar functions in a Learning Resource Centre (LRC) was innovative for the time; and many LRCs of a similar date were mechanically-ventilated and often air-conditioned.

The University determined the main spatial and low energy requirements. At an intensive design workshop in March 1993, the design team resolved the preliminary design strategies, including side lighting with light shelves, two atria, a highly insulated, thermally massive structure, passive solar gain, winter trickle ventilation and stack driven natural ventilation with night cooling for summer. The construction contract was tendered using a performance specification written by the design team, who were then novated to the successful tenderer. An EC Thermie grant was used to help demonstrate low energy design, the results being disseminated under the EC2000 programme.

The completed building (6,000 m^2 gross, 5,600 m^2 treated floor area) runs roughly north-south with two separate atria lying on the main axis. Three and four storeys surround the north and south atria respectively. APU was designed to provide facilities for 750 students, but was operating at a small fraction of this capacity at the time of the Probe 1 survey in summer 1996. To make use of spare space, the University had temporarily housed the accounts department and the Vice Chancellor's secretariat in perimeter cellular offices around the north atrium on the first floor; the third floor of the library was used as open plan offices. Unfortunately the third floor, although easiest to separate, was the least able to cope with such a change of use - being south facing; receiving warm air rising in the atrium; and lacking the thermal mass of coffered ceiling slabs of the lower floors. Consequently, staff working there reported significant summertime discomfort. It seemed that here (as frequently occurs with fit-outs) the occupants or their advisers made changes without proper reference to the design strategy for the building.

APU's innovative natural ventilation and daylighting features lead to classification as an ANV. Its low energy credentials are enhanced by the use of condensing boilers, evaporative cooling in the mechanical ventilation serving the kitchen, and pre-heat of HWS using waste heat from the bar cellar chiller condensers - an energy saving technology developed for pubs in the 1980s. Fabric insulation levels are also good with wall, roof and floor U-values of less than 0.3 W/m^2 K, and triple glazing (using cost-competitive Scandinavian 2+1 aluminium-clad timber windows) specified throughout. Unfortunately contractor cost saving meant triple glazing was omitted from the north facing conference room (where the details were different); but there was no corresponding increase in radiator sizing, leading to underheating.

Building Management System. This is a computer system used for control and monitoring of building services plant. It permits more flexible control, management, and reporting than traditional stand-alone controls, and is often supervised from a PC at a central point - often the facilities manager's office. Most Probe buildings have BMSs - for the offices all except ALD (though the VVT zone controllers have some BMS characteristics) and MBO. FRY's was retrofitted.

Good performance of the ANV features has been hamstrung by the widespread industry problem of poor controls performance and commissioning, which can be more serious for ANV owing to their high dependence on effective operation: with mechanical systems, comfort can often be salvaged at the expense of increased energy consumption - as the Probe AC and MM buildings have often confirmed. The lack of local over-ride facilities for the occupants could make this worse; for example on occasions when the windows opened automatically when building work outside was creating noise and fumes. In particular, night venting was not working two years after initial occupation (and this might not have been properly diagnosed if it had not been for the investigations of the building physics researcher under the EC 2000 programme). The lighting controls also did not function well and the heating flow temperatures were set too high to ensure boiler operation in condensing mode. Nevertheless, energy performance was good, though partly related to the low occupancy levels at the time.

However from the client's perspective (and the contractors to which they have outsourced their operation and maintenance), a new building like a new car shouldn't require much attention, particularly when compared to the University's older properties. The fact that innovations will always need care and fine tuning to bring them into life seems to be lost on the building industry and its clients; under-rated by designers; and often suppressed by procurement and contractual mechanisms. While standardisation and best practice can potentially make many more things "right first time", it must be better recognised that innovative, unpredictable and non-repetitive aspects of buildings are always likely to require a development period of "sea trials" and fine tuning.

John Cabot City Technology College (CAB Probe #11)

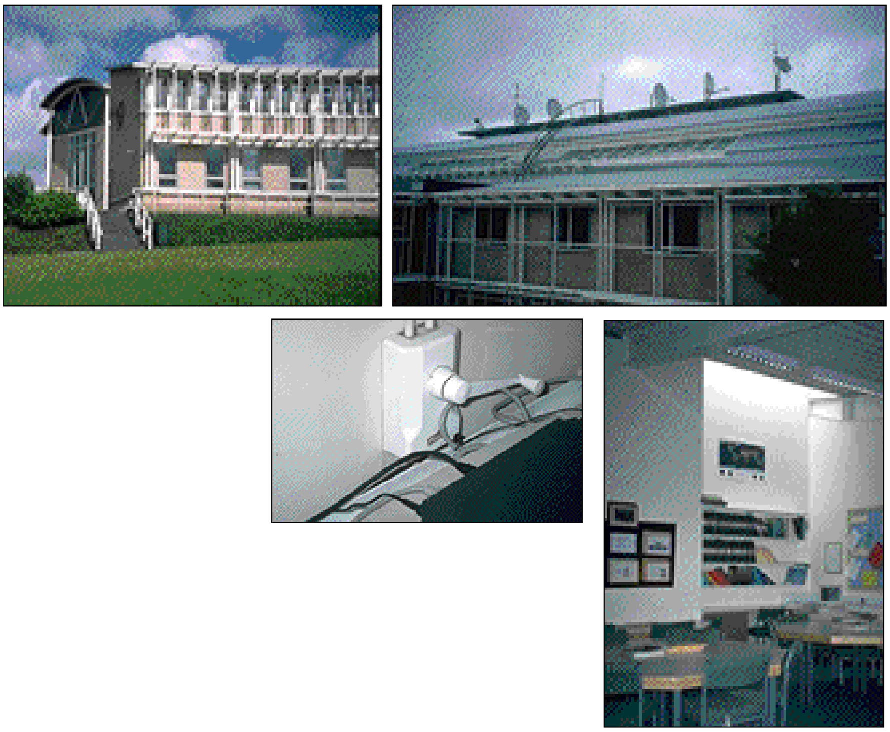
CAB, in Kingswood, Bristol was the last of fifteen City Technology Colleges established between 1986 and 1993 as centrally funded, independently managed secondary schools providing an emphasis on technology and business education within large urban catchment areas. CAB opened in August 1993 and has been filling up by a 150 strong intake of pupils each August. It will reach its full complement of 900 pupils in August 1999, and is already planning for expansion to cater for a staying-on rate to sixth form of 85%, not the 50% anticipated in the brief. Academically the college is doing well, with glowing OFSTED reports.

The classrooms are in three two-storey wings arranged as radial fingers projecting south from a central street running east-west with the main assembly hall and dining room at the eastern end and the sports hall at the western end. Staff room, administrative offices and library are in a two storey crescent to the north of the street. Gross area is 8900 m2, treated area 8800 m2.

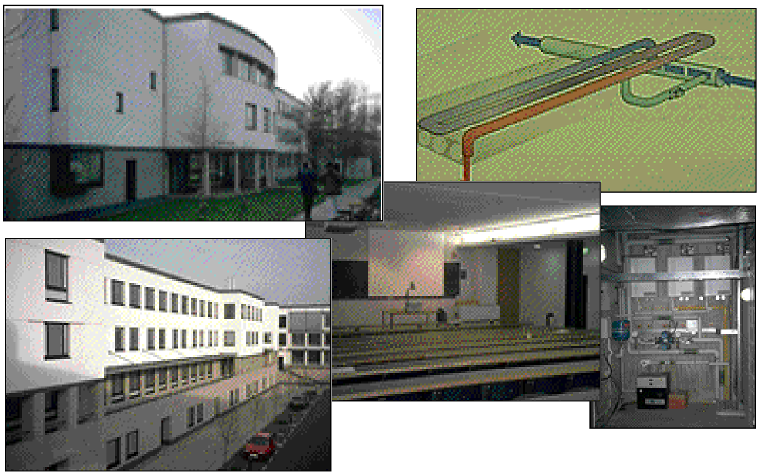
The design team aimed to provide a stimulating internal environment for multiple educational activities using daylight, sunlight and high-ceilinged naturally ventilated spaces. Good energy performance was a secondary objective. The strategy was also to give occupants local control of ventilation and solar control blinds to mitigate any overheating risks. Local manual lighting controls were also favoured for this reason, but the heating plant is linked to a 200-point BMS to provide central control and monitoring functions. Throughout there was a desire to express the technology, including the building structure and services, as part of the learning environment. For example structure is often exposed; view windows were provided into the boiler plant room; and a BMS repeater panel displaying key parameters such as weather conditions, internal temperatures and energy consumption was located in the main street. Unfortunately, as at APU, insufficient attention to detail in the implementation, commissioning and usability of services and the BMS mean that maintenance staff have little confidence in the BMS; and the repeater panel has never functioned reliably.

CAB was the first Probe building to have a pressure test, by BRE. This confirmed high leakage rates through ridge ventilation dampers; even those which the school had plated-over with cover panels during the first winter, in an attempt to reduce cold draughts. The lesson - sadly not a new one - was that conventional HVAC dampers - even low-leakage ones - when used to control natural ventilation rarely close tightly, and that sizing free areas for the summer condition can lead to uncontrollable winter situations. In fact, and as often happens with windows, leakage occurred not only via the damper mechanisms but also around the outside of the assembly, where it was built into the structure. Neighbouring residents also objected to noise break-out through the dampers in the main hall, particularly for evening events, and they too had to be sealed.

John Cabot City Technology College (CAB Probe #11)



The Elizabeth Fry Building (FRY, Probe #14)



The Elizabeth Fry Building (FRY, Probe #14)

FRY is the most recent low energy building commissioned by the University of East Anglia at Norwich. Occupied in January 1995 the four-storey building contains academic accommodation, with two 120 seat lecture theatres, two smaller lecture theatres and numerous seminar rooms on the lower ground and ground floors and some 50 cellular offices for about 70 staff in the schools of Social Work and Health Policy and Practice on the first and second floors. The building was designed to accommodate up to 1,000 students, although a typical maximum is closer to 600. Gross floor area is 3250 m^2 , treated area 3,130 m^2.

The building has a clear environmental control strategy, with a well insulated, thermally massive and airtight envelope to minimise external heat losses and gains, low-e argon-filled triple glazing, ventilated hollow-core floor slabs with exposed soffits to provide better radiant conditions in the spaces and more effective heat transfer with ventilating air, and 'trickle-charge' mechanical ventilation via the cores to achieve stable year-round internal conditions (with added heat if needed in winter and night cooling in summer). Occupants can also use opening window elements for local ventilation as needed, making this a mixed-mode building.

With high efficiency heat recovery in the AHUs, the design heat loss fell to just 15 W/m^2, met by three domestic gas fired condensing boilers with an installed capacity of just 23 W/m^2 including 50% reserve (most other Probe buildings have between 100 and 200 W/m^2). The high insulation and thermal capacity also made it possible to simplify the systems by avoiding perimeter heating. There is a separate direct gas fired storage heater for the kitchens and main toilets.

The energy and comfort performance has been well documented by monitoring for BRECSU, upon which the PROBE study has drawn, while also making independent checks. The monitoring identified control problems, and after attention by the occupier, the controls specialist and the design team, normalised heating gas consumption was reduced to just 33 kWh/m^2 in 1997. Total CO_2 emissions (including HWS gas and all electricity use) were 44 kg/m^2/yr - just over half a low to medium academic benchmark and comparable to an ECON 19 good practice naturally ventilated office. Low HVAC electricity usage is ensured by good specific fan powers of around 2 W/l/s (higher than the desirable target of 1 W/l/s, but well below typical 3 W/l/s), low supply volumes determined by minimum fresh air requirements only, and variable volume supply with automatic air quality control to the intermittently occupied lecture theatres.

Exceptionally high occupant satisfaction with comfort in the offices arises from a combination of good stable background levels of services (especially fresh air and modest artificial light levels) and provision of sufficient adaptive opportunity for users to fine tune local conditions (via opening windows, blinds and manual light switching) which means that users are rarely exposed to discomfort. Cellular office accommodation (usually preferred to open plan) and good building management by the Estate's team are also important contributing factors. Students regarded comfort levels in the lecture rooms as similar to others in the university.

Overall FRY presents the best example yet of virtuous processes with careful briefing, team selection, design, construction, commissioning, monitoring and operation leading to unusually high levels of satisfaction, together with low energy consumption. Nevertheless, even here, there was considerable scope for yet more reductions in electricity use and carbon dioxide emissions, particularly for lighting installed capacity and control, and specific fan power.

The Portland Building (POR, Probe #18)

The Portland Building was commissioned by the University of Portsmouth to house the School of Architecture and the Department of Land and Construction Management in a single building which also includes shared learning and teaching resources for the whole Faculty of Environment. The building is on a former car park next to existing faculty buildings in central Portsmouth. Occupied in July 1996, it houses 60 staff and serves 870 students from the two departments. Including those from other departments, some 1,200-1,300 students use the lecture theatres each day.

POR has 6,230 m² gross floor area in an E-shape plan form with north and south wings housing four storeys of classrooms, design studios and staff offices, a west facing spine housing a three-storey resource centre with two 80 seat lecture theatres, four large seminar rooms above them, and a galleried library in between. The central wing of the building houses a 200 seat displacement-ventilated comfort-cooled lecture theatre, above a ground floor café. In the centre of the E between the wings is a full height galleried atrium which creates an enclosed but light and spacious forum.

The building is predominantly naturally ventilated, as signalled by distinctive glazed plantroom turrets at the top of massively-constructed stairwells which double as stack ventilation towers. However, the designers used a variety of environmental systems and experiences both to deliver acceptable comfort and to be of value didactically to the students. These run from wind protection only in the courtyard to the fully mechanically ventilated comfort cooled main lecture theatre, so the building is very much a mixed mode one.

Mixed-mode ventilation and cooling is deliberately designed to combine the benefits of openable windows and mechanical systems. In concurrent designs, the mechanical systems run constantly (at least during the occupied period), and the windows can be opened as well.

Insulation levels are reasonable with wall U-values of 0.33 W/m² K, air tightness was tested and found to be about average; and total boiler output of 123 W/m² confirms the average performance levels. Unusually the building has solar panels in four of the five ventilation towers which pre-heat the hot water. Surprisingly, however (and despite extensive underfloor heating) none of the twelve boilers (distributed amongst plantrooms at the top of each of the five ventilation towers) is condensing; although condensing boilers would have been likely to save more gas at less cost than the solar panels. Is it not time that condensing boilers are simply accepted as standard?

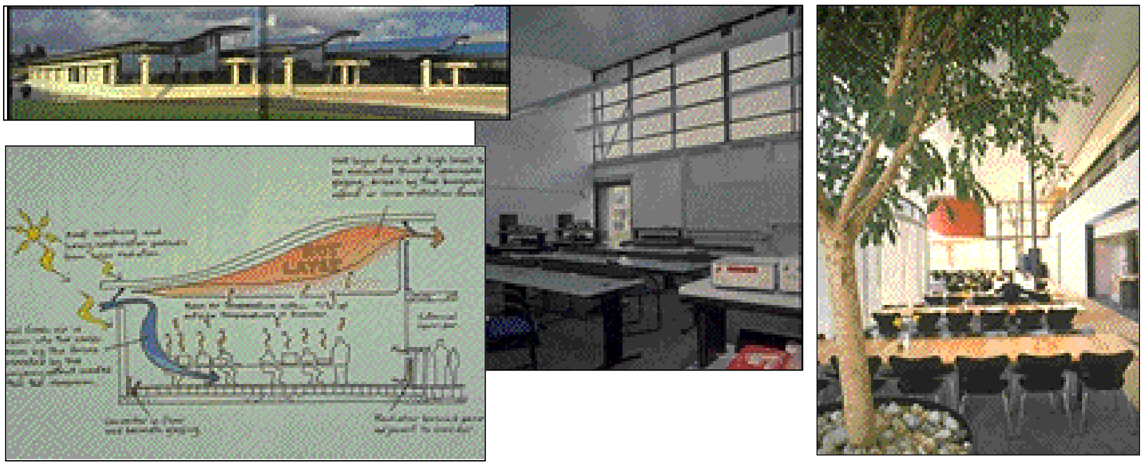
The daylight is good. The design strategy was to give occupants as much control as possible over their comfort conditions, so in many spaces local wall switches are combined with effective occupancy sensing controls. Although somewhat haphazard in operation, these worked quite well to reduce lighting energy use. Ventilation and solar shading is also locally-controllable.

Originally most controls were local: only the main boiler plant and associated toilet extract fans and make-up units were on the central campus BMS system initially. Progressively the estates team has been installing further outstations to improve control of the advanced passive design features such as atrium vents, atrium solar shading and external solar shading, for which the local controls had proved inadequate. Sometimes, however, the local controls have been sealed-off, owing to the Estates Department's desire to have responsibility for the building's security and protection. This raises interesting issues about central and local occupant control - which cropped up frequently in Probe. The Probe team's view is that there are major benefits in combining central and local controls appropriately, but that doing this requires much more attention to strategy and detail than the industry can normally afford to provide.

As at APU, the already overstretched Estates Department had assumed that this new building would need little attention and did not allocate much time to fine tune and fully understand the building's performance. For this building, they had also been little involved in briefing and procurement, which owing to the former polytechnic status, had largely occurred between the Faculty and the designers, Hampshire County Council. Further evidence of insufficient commissioning was given by the non-operational electricity submetering; the poorly-understood automatic control of lighting, solar shading and library ventilation; and user over-rides which sometimes proved to be ineffective in operation.

The Portland Building (POR, Probe #18)

Cable and Wireless (C&W, Probe #6)



Cable and Wireless (C&W, Probe #6)

The Cable & Wireless residential training college on a business park outside Coventry was commissioned to replace their original training centre at Porthcurno, Cornwall. The site was selected from over 100 alternatives, primarily for easy communications. The building provides high quality facilities for courses in technology, management and marketing for all parts of the Group. Occupied since December 1993, the building has been widely acclaimed and won the Sunday Times Building of the Year award in 1994. The designers used an innovative wave roof form to provide natural ventilation of the main teaching spaces, responding to the client's brief for a low tech but distinctive building. For this reason it is classified as ANV. The NV residential building and the mechanically-ventilated sports centre were also included in the energy analysis (sadly - but normally - they were not sub-metered) but not the occupant survey.

The 12,000 m^2 (gross, 11,400 m^2 treated area) college has three distinct blocks:

- a 7,000 m^2 single storey teaching block to the south of the site, with 2 lecture theatres, 20 classrooms, 22 laboratories, tutor offices and library;
- a three-storey 3,600 m^2 residential block, with 168 study bedrooms, plus restaurant and administrative offices;
- a 1,400 m^2 leisure pavilion with 25 m swimming pool, sports hall, squash court, gym and café-bar.

The college achieves a high level of architectural delight and is finished to high standards. The ANV classrooms are a success in terms of the design ambition - supported by physical and computer modelling - of providing summer comfort in a deep single-storey space with openings at high level only. However, underheating and cold draughts from open windows have occasionally been a problem in winter. High areas of south facing glazing in the restaurant and mezzanine offices have led to summer overheating, which would typically be solved by air conditioning. Staff dissatisfaction with comfort in this area is exacerbated by conflicting environmental demands of the restaurant and the administrative spaces, which share the same space, noise, heat and means of control - manually operated opening windows and blinds.

Mechanical ventilation and cooling were largely avoided for areas with expected internal heat gains of up to 50 W/m^2 . For classrooms in which gains were expected to be higher, a single 47 kW packaged air cooled water chiller provides chilled water for downflow fan coil units. In practice, these high heat gains have seldom occurred, owing to a change in emphasis of the college from technical to management and professional training. LTHW is from modular high efficiency boilers, seemingly missing an ideal opportunity for condensing boilers or even CHP given the steady base load heat demand of swimming pool, catering kitchen and residence HWS.

The 'low tech' philosophy extends to all aspects of services controls. Except in the leisure pavilion, control is left to occupants via local wall switches for vent opening, blind operation and light switching and TRVs for perimeter radiators. So far, unfortunately the lack of "ownership" by short-stay students of the local control and the absence (as in most buildings surveyed) of any energy management policy has led many systems, and in particular lighting, to default to on. In the pavilion, the automated lighting controls were not understood by occupants and so were overridden to the default state of all on for 18 hours every day despite highly variable occupancy. As is normal in swimming pools, the pool hall ventilation ran 24 hours to avoid condensation: however, it could have been variable in capacity. The chilled water to the classrooms also circulated constantly.

Both gas and electricity consumption were far higher than expected: partly because only the classrooms were attempting to improve on normal practice in servicing terms. This situation was exacerbated by the high running hours, default to ON, lack of basic sub-metering and no energy management.

Woodhouse Medical Centre (WMC, Probe #6)

WMC (640 m^2 gross) is the smallest building studied in Probe. The single-storey medical centre on the outskirts of Sheffield is domestic in scale and construction. It is divided into three individual units occupied by two separate GP surgeries and a dental practice. Opened in 1989, it was built to very high standards of insulation (Wall U-value 0.2 W/m^2 K, Roof U-value 0.1 W/m^2 K) and includes several other low energy features such as mechanical ventilation and heat recovery (MVHR), gas condensing boilers and low energy lighting. It was also completed within the strict financial and spatial constraints of the local Health Commission, with no additional funding for the low energy features.

WMC has the lowest CO_2 emissions per square metre of any of the Probe buildings. It is well liked by occupants despite several gaps in their understanding of the design intent - which appeared to stem from little contact between the designers and the building's end users during and after handover. For example, the domestic-style mechanical ventilation heat recovery systems were generally assumed by users to provide a form of year round air-conditioning, and hence to provide improve summer comfort. In fact, they had no bypass, so would actually tend to increase air temperatures. These units had fallen into disuse by the time of the Probe survey.

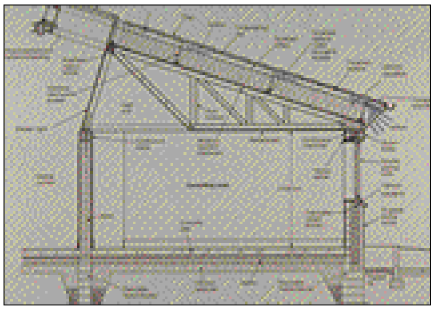
Similarly, the natural ventilation strategy was to use casement windows (sometimes now with their movement restricted by added external security bars) and if necessary to cross-ventilate with outlets via openable roof windows near the ridge in corridors and public areas. However, the roof windows were not used because they are high up and impossible to reach. Although operating poles or motors could quite easily have been added, after completion nobody had got round to doing it, and consequently summertime temperatures could be high. In addition, the intended cross-ventilation of doctor's surgeries via high-level windows to the corridors was not possible owing to the need for acoustic privacy. One practice decided to retrofit split DX room units in two spaces: but since these were only used in times of need, their contribution to annual energy consumption was low. The generally high satisfaction levels, despite the summer discomfort, is probably due to the general domestic style of WMC and its consequent familiarity, as discussed in Reports 3 and 4.

Several other services issues are noteworthy:

- High electricity use by the 27 local electric water heaters, each with standing losses of 0.5 kWh each per day, amount alone to 15% of total electricity usage. Time controls would have been beneficial. Using the domestic gas boilers to provide the hot water would probably have been better.
- Artificial lighting levels were low. Since most rooms also require the use of internal blinds for privacy, each practice quickly installed additional lighting including inefficient 300 W halogen uplighters in one practice.

The cellular and domestic nature of the building, with local control in each room, tended to lead to less wasteful operation than in open-planned areas, where everything is more likely to default to ON.

Woodhouse Medical Centre (WMC, Probe #6)



Rotherham Magistrates' Courts (RMC, Probe #10)

Rotherham Magistrates' Courts (RMC, Probe #10)

RMC was occupied in March 1994. It houses ten courtrooms to meet anticipated needs over the next fifty years. The brief - set by a committee of Magistrates - sought a building which avoided air conditioning (it was at a time when concerns about sick building syndrome had a high profile) and provided some daylighting to all court rooms. The designers used EC programme funding to obtain specialist thermal and daylighting analysis to inform decisions about the built form, natural lighting, and sunspaces for both passive heat gains and ventilation air preheating.

Of the building's gross floor area of 5,450 m^2, 1,200 m^2 is circulation space, reflecting the need for three separate circulation zones for the magistrates, defendants and members of the public. These are elegantly resolved: the building has a courtyard at its centre; the south-facing double-height glazed sunspaces with galleries are used for public circulation and waiting areas and demonstrating the passive design concepts; and the magistrates rooms and circulation systems have views on the north side. However, the ushers did comment that the courtyard plan had made people more difficult to find than in a more compact arrangement with a central core of waiting areas.

Following initial tendering, a budget cut of £ 1 million was imposed, which led to changes in the solar and low-energy strategy, with some compromises:

- The sunspaces were reviewed and it was found that their glazed roofs were not necessary. Without them, overheating risk was reduced, daylight to the public areas was still good and ventilation and solar shading could be reduced. This was probably an improvement.
- The separate mechanical ventilation systems for waiting and courtroom areas - with heat exchange from outgoing sunspace air to incoming courtroom air - were combined.
- Roof windows were omitted from the offices with high ceilings rising into the roofspaces. This proved a false economy, and after the building had been through its second summer fifteen wall-mounted split system air conditioners were fitted.

Mechanical ventilation to the courtrooms and public areas is largely via floor-mounted displacement ventilation terminals using 100% fresh-air with heat recovery from exhaust. A chilled water system also provides cooling to the AHUs in hot weather, but is quite sparingly used. The cost-cutting and associated changes compromised the original operating strategies which were originally intended to treat the sunspaces and the courtrooms separately. In winter it was intended to exploit the passive sunspaces by using solar and exhaust air heat recovery to preheat fresh air, whilst in summer sunspaces would be entirely naturally ventilated and the courtrooms would be supplied with chilled fresh air and extracted to ambient via a by-pass to the heat exchanger. However the systems as finally installed are unable to serve separate zones or to bypass the heat exchanger. They also supply a generous average 4.5 l/s per square metre of the total area despite low occupancies. Hence there is high fan energy consumption and associated air tempering loads, particularly heating. This is exacerbated because even though the system is zoned to some extent, if any one courtroom is used, it typically requires the ventilation systems for two or three others and their associated waiting areas to run.

Generally daylight availability is good, although the requirement for daylight in each courtroom leads to some complex internal arrangements particularly with respect to fire compartments. The use of nearly sixty different lamp types is also troublesome for the building managers. Average IPDs are reasonable at 11 W/m^2. Lighting control is manual and fairly high numbers of lights were unnecessarily on during Probe visits: inconsistent switch layouts between otherwise identical rooms leads to confusion in use. Nevertheless, lighting energy use was relatively low owing to the intermittent occupancy of many of the spaces, the good daylight in the public areas, and the availability of local switching.

Occupant comfort in the courts, public areas, and magistrates' areas is high. Comfort in the offices is now high too - though at some cost in terms of energy consumption - following the fitting of local air conditioning which is available on-demand via local controls for each unit.

It was disappointing that the gas consumption in this low-energy design was only just below the "high" benchmark level in the Yellow Book for Crown and County Courts, and electricity somewhat above the "high" benchmark. The main reason for this was the mechanical ventilation: the high air change rates having high air tempering requirements, in spite of the cross-flow heat recovery. The electricity used by the fans was also high, owing to:

- The high air change rates.
- The relatively high specific fan power (3.8 W/l/s)
- Relatively long hours of use (averaging 11 hours/day, even though courtrooms are only required for a maximum of six hours and typically only half are in use at any one time.

At RMC - as in many buildings - it seems that designers and their advisers frequently fail to consider the energy - and in particular the CO_2 - costs of air handling in sufficient detail. This sometimes leads to fan anathema - as in some of the ANV buildings - although efficient slow-speed extract fans at high level could often perform a similar function using little energy without the capital and maintenance costs of stacks. On the other hand - as at RMC - fan energy can slip through the net. For example, one of the main reasons for RMC's ventilation system design was to recover heat from the sunspaces and save 5 kWh/m^2 of gas (1 kg $CO2/m^2$) per year. However, in the completed building the fans was used nearly 40 kWh/m^2 (20 kg $CO2/m^2$), so the benefit of the solar preheat to the environmental bottom-line was equivalent to a 5% reduction in annual fan energy, whereas a good practice air handling system would have produced at the very least a 50% saving; and operating hours could probably been halved as well if control could have been more demand-responsive.

Marston Books Services Warehouse (MBW, Probe #16)

The offices at Marston Book Services (MBO) are attached to the corner of a large warehouse (MBW) of fifteen times the office building's volume. The warehouse provides goods inwards, pallet racking, retrieval, packaging and despatch of books to customers. Importantly MBS felt that the warehouse should be built to similar standards of fabric insulation to the offices, which has resulted in good performance. Heating consumption is around half the benchmark level for a new warehouse: though this is partly the consequence of the relatively low internal temperatures set (10-12°C), with boosting under occupant control and regularly checked by the supervisor. Measured air leakage, although higher than best practice standards (achieved, for example, by some supermarket chains) was also good for a UK industrial building.

Summer conditions in the warehouse can become uncomfortably warm for the staff who work there, particularly the 25 or so on the daytime shift; and the fork lift operators who rise to the top of the racking with their cargoes. Natural ventilation through windows and loading doors is concentrated at the north-west corner of the building. Motorised roof ventilators would have been helpful, but MBS wanted to protect their stock from the risk of rainwater ingress. The destratification fans provided with the warm air heating have also not been entirely successful, owing to obstruction of downflow by the mezzanines.

In common with many warehouses, the lighting has relatively low illuminance levels (150-200 lux) and installed power densities (5 W/m^2), but is all on just two switches and so has long hours of use even though much of it, particularly above the racking, is only occasionally required. More demand responsive controls would have been beneficial.

Owing to the slow run-up time, the SON lighting is also switched on automatically each day on a 24-hour timeclock. There is no Saturday morning shift, so the supervisor has to call in then to switch the lights off. This no doubt also has other advantages for security, checking the work of the previous night shift, and setting things up for the Sunday night's work. This again illustrates how easily minor problems in buildings can persist, with occupants finding practical but non-optimal ways of living with them rather than considering simple alterations, for example a 7-day time clock here (or window poles at WMC).