#6747

It was important that this method be finalised before detailed design started, since using a hoist places certain restrictions on what equipment can be used, ie will it fit on the hoist? For instance, the chillers and condensers had to be broken into sections, each one having to weigh less than 2·5 tonnes.

Plant is moved around at roof level by a steel A frame that spans the width of the roof and runs on the rails installed for maintenance gear. This can operate in winds of up to 25 mph.

Chillers have been slightly oversized to allow for future derating when changing from the interim refrigerant R22. One interesting aspect of the condenser specification is the flexibility of the cooling coils; despite anti-vibration mounts, Carrier is conducting assessments on the degree of movement in high winds.

The chillers are up on capacity when compared with the old plant, the increased office machinery generally pushing up cooling loads. Indeed, the original design had only allowed for 5 W/m^2 of cooling for office equipment.

As the building is fully occupied, the changeover of plant has to coincide with the seasons. Work started on the cooling equipment last October, and the chilled water has to be flowing for the cooling season at the end of April.

However, the system will require quite some balancing act. The original design did not include any commissioning stations and, over the years, numerous bypasses have been added that are not accounted for on the drawings. These have to be located and removed.

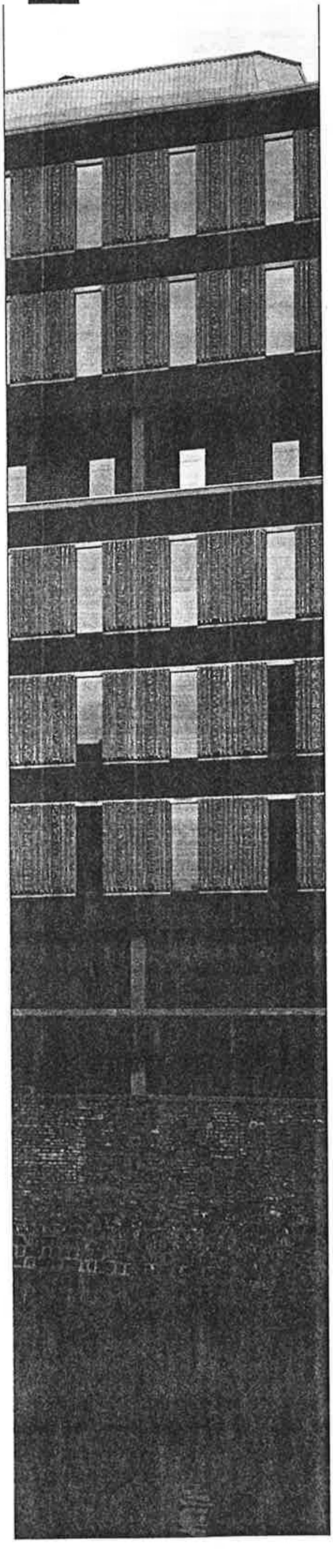
When carrying out essential works, you have to plan for future work and look at areas which it makes sense to take care of at the same time. For example, the boilers had not been a top priority replacement item but, since they were located in a plantroom area just below roof level, there would be no access to them once the condensers were in place.

Hence the old sectional boilers have been torn out and replaced by three Hoval low NOx boilers, two at 1200 kW and one at 750 kW. Low NOx specification was based on expected future EC legislation.

Work continues until the end of July on this works package. Fire alarm systems are being replaced, a 400 kVA standby generator installed for life support services and lighting and power in the landlord's areas is being replaced.

A welcome addition is the bms, with electronic control valves replacing the original pneumatics. At least the maintenance team will no longer have to manually switch over the two-pipe induction system from cooling to heating on some designated day in September!

Client
MEPC
Services consultant
FHP Partnership
Management contactor
Bovis Construction
M&E contractor
How Engineering Services



Changing gear

by Roderic Bunn

Can a 1970s air conditioned office block be converted to natural ventilation? What are the architectural and cost implications, and will the building fabric be able to cope with the internal heat gains? Roderic Bunn reports on the latest design work.

With demands for new commercial offices unlikely to pick up much before 1995, refurbishment work will probably predominate in the near future. If so, the office blocks of the 1970s will be ripe for refitting. But what building services will we need to install?

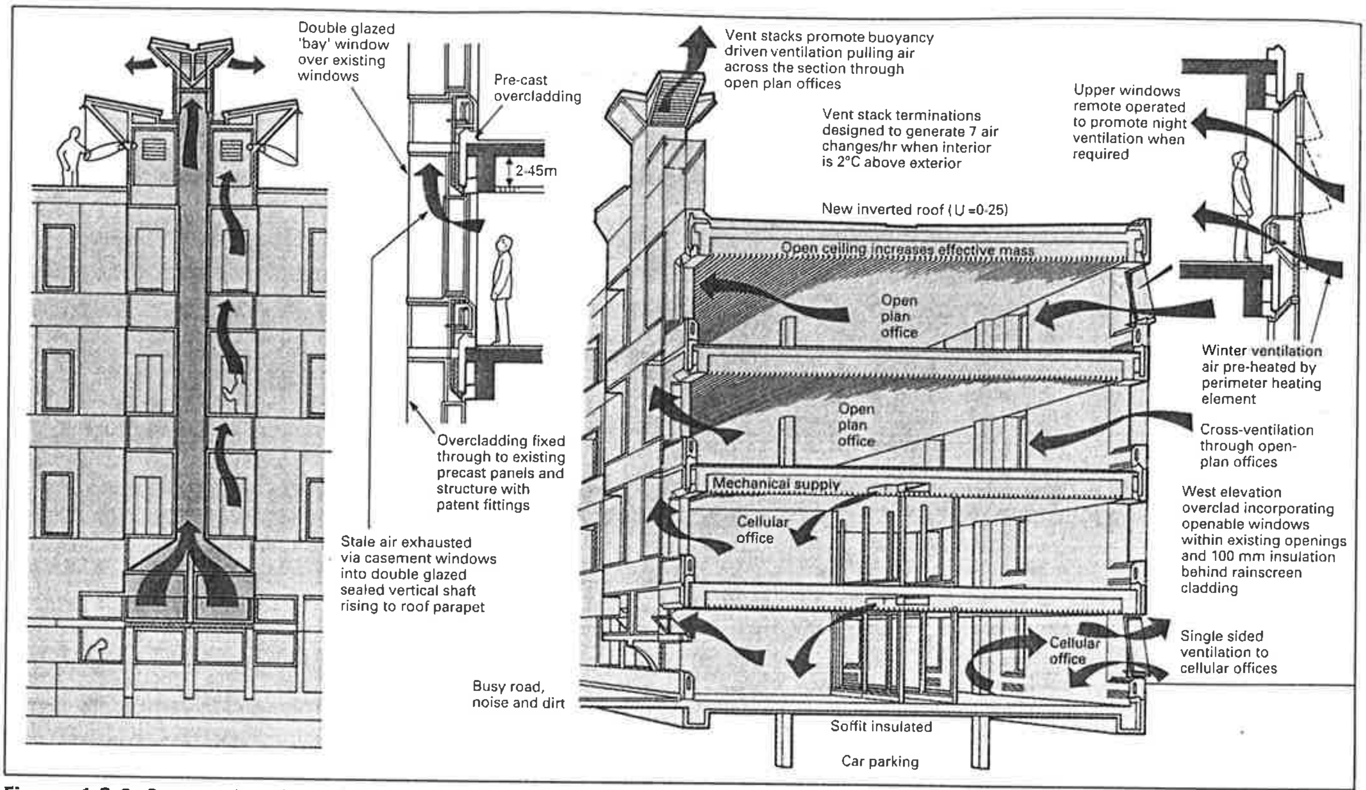
Back in 1988 the Department of Energy initiated a series of major projects as part of a passive solar research programme. The aim of this work was to demonstrate that passive solar design can produce attractive buildings with minimal energy requirements and high standards of comfort and amenity at a reasonable cost.

The design studies covered three building types:

☐ Group A: light industrial;
☐ Group B: non-urban offices (business parks);
☐ Group C: urban offices.

The work was co-ordinated by Halcrow Gilbert Associates for the Energy Technology Support Unit, now on behalf of the Department of Trade and Industry following the disbanding of the DEn.

The study looking at refurbished build-



Figures 1 & 2: Cross-section of Temple Way House as converted by Short Ford Associates to a naturally ventilated building. Figure 1 on the left shows how the ventilation stacks would encourage air to vent from the building. Between adjacent bays a square plan duct is formed to exhaust air from the ground floor. Powered extract could be necessary for smoke removal.

Figure 2 on the right shows the proposed cross-ventilation strategy and details of the east and west facades. The designers have attempted to maximise the limited daylight potential by replacing the tinted glass with clear glazing, and by minimising the obscuration of the existing openings created by using new window frames and the glazed bay stacks.

ings was contained within Group C – the urban context. It involved a design team producing a refurbishment concept from a brief set by a quasi-client. By working this way, the project would have to conform to the market pressures that prevail during a real refit project.

As such, the design was to undergo a rigorous and detailed energy and environmental assessment, as well as a capital cost analysis at the interim and final stages. Comparisons would be made to conventional refurbishment strategies of reference buildings so that energy and cost savings – or increases – could be determined.

Consulting engineers Halcrow Gilbert Associates were the project managers, with architects Short Ford Associates chosen for their impressive portfolio of low energy design and refurbishment. Davis Langdon & Everest concentrated on the capital cost assessment and BAe SEMA handled the energy and environmental analyses.

Step one: finding a building

The first step was to find a typical urban office building due for refurbishment, for which Temple Way House in Bristol's city centre turned out to be a suitable candidate.

Owned by the Argent Group and tenanted to the Clerical Medical Investment Group, Temple Way House is typical of constructions of the early 1970s: an urban location, concrete construction, sealed bronze-tinted glazing and an air conditioning system now approaching the end of its life.

12 200 m^2 of gross floor area is spread over an L-shaped plan with one seven-storey tower – measuring 24 m by 29 m – and two five storey towers, each with a core area. The towers (or pavilions) are connected by four storey rectangular blocks of 12·2 m depth. The building has a flat roof with an eaves height on the tallest tower of 23 m.

The 95 m-long east facade, which forms the longer side of the L-shape, looks onto a dual carriageway, while the shorter 55 m-long wing faces a relatively quiet side street. The enclosed sides of the L look onto traffic-free spaces to the west, bounded by the Bristol floating harbour.

The concrete, panel-clad facade has been polluted by fumes and noise from the adjacent inner ring road, so it is not surprising that the fabric is now suffering from chlorination and carbonation problems.

The structure has very poor fabric U-values, and a lighting scheme with an installed load of 28 W/m^2. The net window area is only 20% of the external facade, and there is a downstand beam at 2·45 m above finished floor level which severely restricts daylight penetration.

For a reason known only to the original architect, one floor of each tower is stepped back, a feature which contributes little except to reduce further the daylight penetration on that floor.

From this description it may appear that the building was more a candidate for demolition, but that was not what the study was about. Instead, the designers had to try and compare a passive refurbishment approach with a more conventional refit; a tough task given the building's limitations.

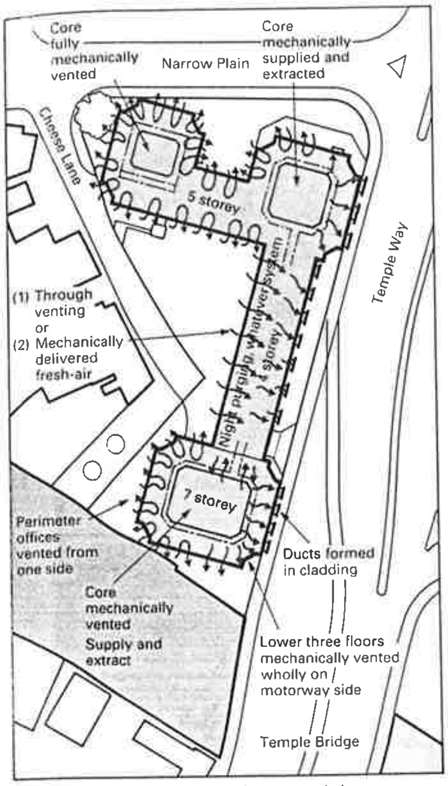
Step two: the options

Being deep-plan in nature, the towers were always going to require forced ventilation and probably some local air conditioning, but it was thought that the link blocks could be naturally ventilated. Fortunately they faced a relatively clean and quiet west elevation, so the option of cross-flow ventilation readily presented itself.

Therefore, attention focused on improving the daylighting, which inevitably meant the pre-cast cladding would have to be completely replaced – no bad thing given its state of repair. However, this would have cost £600/m^2, a figure the client was not willing to entertain given the prevailing market conditions.

The next best option – at a more palatable £400/m^2 – was to overclad the east elevation, providing a glazed bay within which ventilation stacks could be incorporated to aid cross-flow ventilation. Fresh air can be drawn from the relatively clean west side and into the building, and then extracted up the stacks by natural forces, either by buoyancy or wind-driven means (figures 1 and 2).

Arriving at this proposal was not difficult (planning permission notwithstanding), but proving that it would work under all seasonal conditions, and under worst-case equipment and occupancy gains, was another matter.



Site plan of Temple Way House and the ventilation strategy for the whole building.

Photo: Kevin Wilton

Temple Way House: on the short list for carbuncle status by virtue of its generous glazing, crafted pre-cast concrete panelling and versatile stepped-back feature.

Ventilation strategy

In winter, air will enter on the west side through motorised vents below cill level, with pre-heating by perimeter radiators above the inlet vents. On the east side, manually-operated trickle ventilators modulate the flow of stale air out of the zone into the duct from the ground floor, or the bay stack on other floors. At the top of the bay stacks, motorised louvres provide equivalent control.

In summer, occupants of west-facing offices directly control the opening of windows to achieve high air change rates. Motorised top-hung windows at the top of the bay stacks have been sized to achieve the required summer air change rates under worst-case 'no wind' conditions.

The reinforced concrete floor beams and cladding in the link blocks provide sufficient thermal mass to make the building behave as a heavyweight structure. To make use of this, and to maintain acceptable conditions during the summer, the design relies on passing air through the building during the night to purge the daytime heat gains (figures 3 and 4).

This design assumes that a suitable self-adapting algorithm is developed for the building management system to decide when and how much night-purging is used to prevent over-cooling, and to modulate the cill vents and motorised dampers.

The issue of partitioning is extremely important; the natural ventilation approach could easily fail if the client decided to assemble cellular offices willy-nilly. The designers propose that partitioning would be mounted on top of a 200 mm-high plinth with an acoustically absorbent lining. HGa are currently using a computational fluid dynamics package to analyse the viability of this arrangement.

Should the client's refit brief ask for cellular offices on both sides of a central corridor, single-side ventilation would be used for the west-facing offices, while the east-facing offices and the corridor would have a ducted air supply fed from the plant room via the core zone. The shafts would provide the naturally induced extract.

Testing the theory

The design team ran a series of computer simulations on the proposed building to determine the risk of overheating. This was done using the SERI-RES program (see box story).

The essential criterion set in the performance assessment was that no zone should have more than 20 h/y above 27°C, although it was recognised that comfort depends on many other factors that can go beyond the scope of computer models. The quasi-client requested that the number of hours per year above 23·5°C should also be calculated, as this would give a fair comparison with the building's current performance and make the design easier to sell to a prospective client.

Although no guidelines exist in the UK for when the number of hours over 23°C becomes unacceptable, it is worth pointing out that, in the Netherlands, unacceptable overheating is defined as occurring when either hours above 25°C exceeds 5% of working hours (117 h in this study), or when hours above 28°C exceeds 1% of working hours (23 h here).

The results are shown in Table 1. The base case design does not overheat according to the given criterion, as none of the zones experience more than three hours over the year at a temperature above 27°C. Even periods spent over 23°C are apparently modest (less than 100 h/y in the main zones).

To be on the safe side, the design team calculated how the building would perform if equipment gains rose from 15 W/m^2 to 25 W/m^2 and 40 W/m^2. At 25 W/m^2 the simulation program predicted a minimal impact on hours over 27°C, and only at 40 W/m^2 do hours over 23°C reach levels which would give cause for concern (figure 5).

The computer model assumes that the natural ventilation rate would be adjusted so as not to exceed the minimum fresh air requirements when the outside air temperature is higher than the internal temperature. This is simply because greater flows would be counter productive. In reality, say the design team, occupants may not behave in such a logical way, which might cause marginally higher temperatures to occur. On the other hand, higher air flows may indeed provide better thermal comfort.

Table 1: Temperature statistics for the design

Building zone	Hours >23°C	Hours >27°C	Max temp (°C)
Pavilion	99	0	26·7
Open-plan link block	99	0	26·8
Ancillary space	0	0	22·9
Meeting room	118	3	27·4
Cellular office	113	0	27·0

The existing lighting demand for the open-plan areas was an amazing 69·1 kWh/m^2/y, largely brought about by an aged lighting installation and the absence of any useful daylight.

A new high-frequency scheme with optimised spacing reduced the installed load from 28 W/m^2 to 9 W/m^2, while still giving working plane illuminance levels in the office spaces and corridors of 350 and 300 lux respectively. Without daylighting this alone would have slashed the annual lighting demand to 25·8 kWh/m^2/y.

The daylighting potential was determined from the simulation program Daylight. Despite a rapid fall off in daylight penetration due to fabric limitations (to 0·5% within 4 m of the windows), it was felt that the perimeter fluorescent fittings in the 12·5 m link blocks would benefit from daylight controlled dimming. This was calculated to save 5·5 kWh/m^2/y, bringing the total load down to 20·3 kWh/m^2/y – over three times lower in the design than in the existing building (figure 6). Interestingly, the study showed that the density of fittings had a greater effect on costs than did fitting type.

Costs

So how did all the costs balance out? The basic capital cost for the design refurbishment was estimated at £5·6 million (£456/m^2 gross floor area, or gfa). This compares favourably to estimates for a conventional refit, which was estimated at £6·8 million (£561/m^2 gfa).

Total heating, lighting and cooling running costs in the low energy refurbishment amount to £2.12/m^2/y, half the £4.27/m^2/y for the conventional refurbishment. Heating costs are marginally higher, but significant savings are made in terms of lighting costs – nearly 40% lower – and by the avoidance of air conditioning.

When compared with the existing building, lighting costs in the new low energy design are over three times lower, and total running costs are also more than three times less than the current level of £7.66/m^2/y.

The mixed mode ventilation scheme in the design is, at £97/m^2 gfa, considerably cheaper than the full air conditioning in the reference building at £173/m^2 gfa, despite a vertical baffle suspended ceiling system costing £27/m^2 gfa more than a conventional acoustic system.

After everything was taken into account, the refurbishment basic capital costs are lower than *Spon's* average prices for good quality office refurbishments; however the cost assessors felt that the client's budget could be less than these values in current market conditions.

Key messages

The work on Temple Way House showed that, for this onerous site at least, low energy refurbishment costs are lower than *Spon's* average prices for 'good quality' office refurbishment.

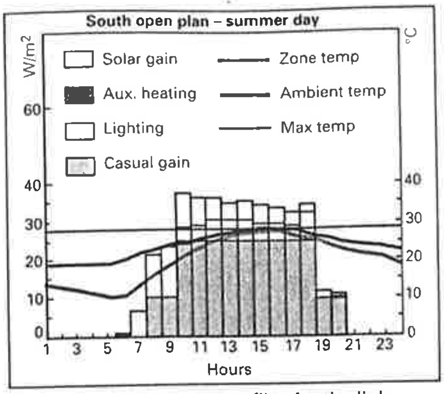


Figure 3: Temperature profiles for the link blocks show how the passive design will perform during one of the warmest days of the year. Night purging was used to pull down the internal temperature to 18°C by 6 am.

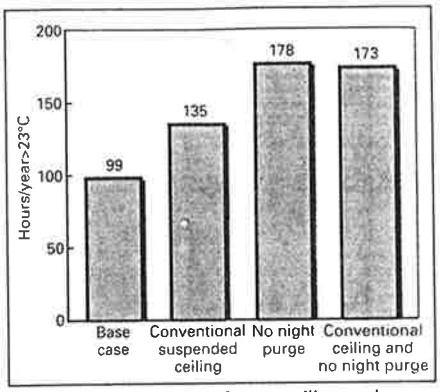


Figure 4: The benefits of open ceiling and night-purging in the open-plan area.

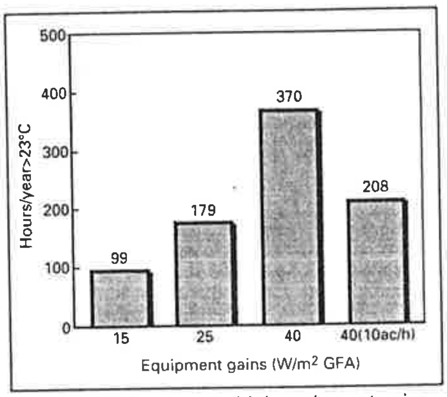


Figure 5: Robustness to high equipment gains in the naturally ventilated, open-plan area.

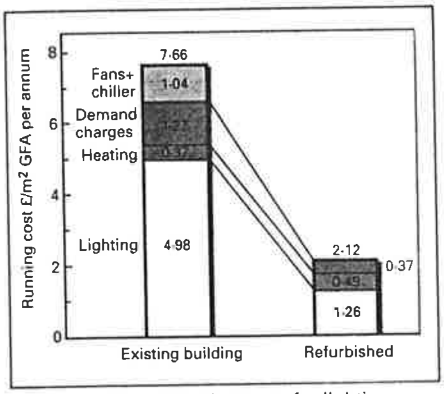


Figure 6: Energy running costs for lighting, heating and comfort.

The energy costs were calculated to be over three times lower than the existing building, mainly due to much more efficient lighting, perimeter daylighting, overcladding with insulation and extensive use of natural ventilation. A conventional upgrade with similar U-values, but retaining full air conditioning would have energy running costs twice as high.

Halcrows stress that night purging, preferably controlled by a bems, would be necessary to exploit a (carefully exposed) heavyweight structure.

Despite a limited window area, the removal of the original tinted glazing and careful detailing of the overcladding or ventilation stacks to avoid creating obstructions would allow most occupants to enjoy a far greater sense of contact with the outside world, reinforced by the ability to open windows and manually control solar glare.

The key issue for the client was whether the team could give a performance guarantee equivalent to the one that would be delivered as a matter of course for an air conditioned scheme.

The design study shows that passive principles can be applied in the most unpromising circumstances. All that needs to happen is for the client and tenant to take the plunge and win the kudos.

This article is based on the case study report prepared by Halcrow Gilbert Associates consulting engineers and Short Ford Associates architects as part of their work for the Non-domestic Building Design Studies Group C: Urban Offices. *Building Services* would like to thank Paul Ruyssevelt and Robert Cohen of HGA and Brian Ford of Short Ford Associates for their invaluable help with this article.

SERI-RES assessment

Devised for the purpose of analysing building energy and environmental performance, SERI-RES employs a finite difference method to simulate energy flows within a building, using hourly weather data and sub-hourly calculation time-steps that relate to the thermo-physical properties of the building fabric.

Natural lighting levels calculated by the Daylight software package are input to SERI-RES along with a user-selected control strategy. This enables lighting energy savings to be calculated based upon hourly sky illuminance data.

Dynamic building simulation modelling is still in its infancy and no program that is currently available can claim to be fully validated against measured building performance. For this reason the performance assessment methodology involves a reference building analysis to enable relative comparisons to be made on a level playing field.

Furthermore, an extensive range of sensitivity studies test the robustness of the computer predictions to variations in key input parameters such as the level of internal heat gains, the maximum daytime and nighttime ventilation rates and the occupant operation of shading devices.