July 1990

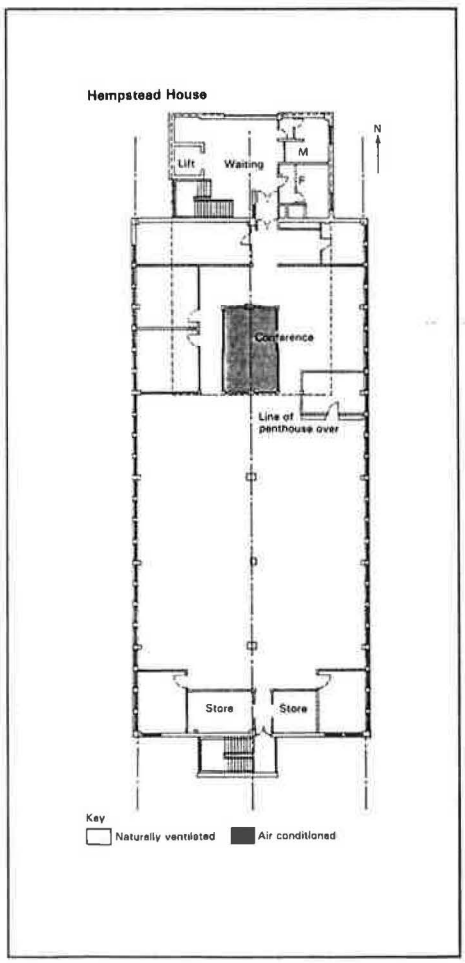
BEST PRACTICE PROGRAMME

Good Practice Case Study 15

ENERGY EFFICIENCY IN OFFICES

A simple new multi-tenanted speculative building with cost-effective building services Hempstead House, 2 Selden Hill, Hemel Hempstead

- **Modular boilers under optimised control.**
- **Independent control of heating on each floor.**
- **Daylight to stairs and reception.**
- **Daylight in offices good but not always fully used.**
- **Metal halide discharge uplighting with automatic time controls on some floors.**



The Project

A speculative office building was pre-let to a firm of consulting engineers, who designed their own building services and influenced the building design to meet their individual requirements.

The consulting engineers upgraded the developer's specification by including double glazing and zoning the central heating. Further savings were made from local electric heating of domestic hot water and by omitting office lighting from the building contract.

Construction is conventional, with concrete frame, concrete floors and brick cladding for the four main floors, plus a lightweight steel roof penthouse enclosing plant, storage and common services.

Insulation is to the requirements of the Building Regulations at the time of construction (1982), plus double-glazed windows throughout. Glazing areas to the offices (at about 40% of the main elevations) are generous and permit good daylight without exacerbating problems from excess solar heat and glare.

The naturally-ventilated offices are 16 metres wide (close to the maximum desirable for cross-ventilation), and largely open-plan. Simple raised floors permit the distribution of cables for power, light, telephones and computers.

The consulting engineers now occupy just over half the building, with the ground and first floors sub-let to tenants: banking services and information technology.

The Result

The application of simple but effective techniques has led to a straightforward, flexible building with a low energy use, particularly for heating.

The total of 164 kWh/m^2 of treated area is well within the CIBSE Energy Code Part 4's 'good' category for an office of this type. (See Fact Sheet).

Unusually for many recent buildings, the staircases and adjacent waiting areas are naturally-lit and the toilets are naturally-ventilated. This is an attractive feature which has also helped to reduce energy costs.

The walls of the roof penthouse were fully-glazed for architectural reasons: this increases heat loss and solar gain and leads to some overheating on the west side. Air conditioners have been added in the print room and are only switched on manually in extreme conditions.

BEST PRACTICE PROGRAMME

Energy Efficiency Office
DEPARTMENT OF ENERGY

C1/Sfb 1976 32 R3 W8 Y7

Heating System

At first sight, the heating system is conventional, with perimeter radiators fed by low-temperature hot water (LTHW). This is provided by four floor-standing modular cast-iron gas-fired boilers in the roof plant room.

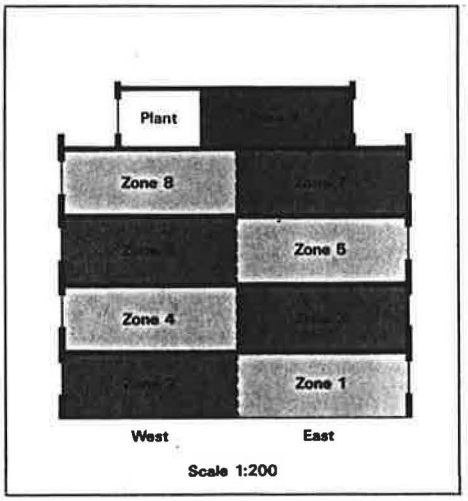
9 separate control zones were created (see diagram), to take account of the east/west orientation of the main facades and of the different tenancies on each floor. LTHW is circulated around a common primary loop in the plant room and main services riser and withdrawn as necessary into the nine separately-pumped zones via motorised 3-way mixing valves.

Heating Controls

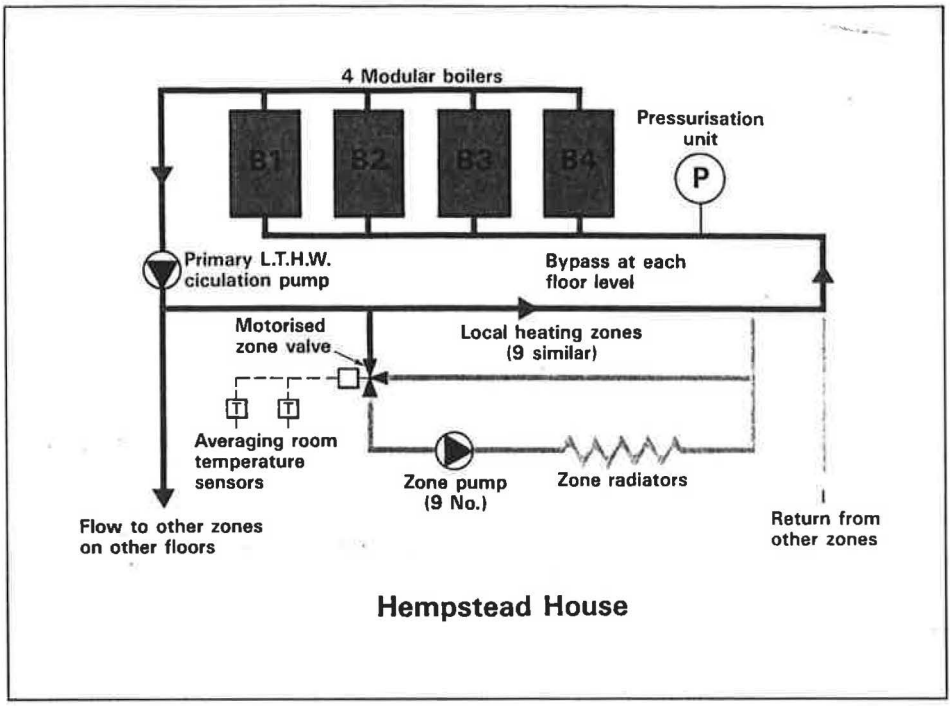
The control panel in the boiler room provides a 7-day time programme, with boiler sequencing optimum start, stop and outside temperature compensation for the perimeter heating. This operates the boilers, the main pumps, and the nine zone pumps for the standard working week.

The 3-way mixing valve for each zone is adjusted by a proportional controller, each with two averaging room temperature sensors. If heat is required, the valve opens to admit more LTHW into the zone from the primary circuit. If less heat is required, the valve closes. If all valves are fully closed the boilers are switched-off.

Local over-ride facilities can isolate individual zones if they are unoccupied and switch on individual zones out-of-hours and on demand without heating other parts of the building.



Hempstead House zoning diagram



Heating system schematic

Domestic Hot Water

The demand for hot tap water in offices is usually small and using central heating boilers to supply it can be uneconomic. Local electric water heaters were therefore installed: eight storage units — one for each toilet — plus six oversink units for kitchens, cleaners and print room.

All the water heaters are controlled from a central time switch to avoid unnecessary heating at night and weekends.

Mechanical Ventilation Systems

Mechanical extract fans are provided only to the print room (to extract fumes from the dye-line machine), and to the lift motor room (thermostatically-controlled to limit summer overheating).

Air Conditioning

Packaged split-system air conditioning units are fitted in the conference room, print room, and tenant's machine room only. These are operated on-demand under their own local temperature controls.

Lighting

Ceiling-mounted fluorescent lights are used for corridors, toilets and fourth floor service areas, with tungsten and mercury-tungsten blended accent lighting in lobby, reception and waiting areas. Circular wall-mounted fluorescent fittings are used on the stairs. Office area lighting varies with the individual tenant as described below.

The ground floor has background lighting from centrally-switched 250-watt metal-halide (MBI) floor-standing uplighters, giving an ambient light level of some 300 lux, supplemented by individually controlled linear fluorescent desk lamps.

The first floor has a conventional ceiling-mounted fluorescent system with prismatic diffusers, giving some 600 lux.

The second and third floors have background lighting from 250-watt metal halide uplighters incorporated in the furniture system, with some additional 150-watt metal halide uplighters on walls and columns. Original design illuminance was reported to be 300-500 lux. However, at the time of our survey this had nearly halved because the lamps were approaching the end of their useful life (3 years), and the fittings and ceilings had become dirty.

The background system is supplemented by adjustable desk lights with miniature fluorescent lamps. In spite of the reduced ambient level, only about one-third of the desk lamps are typically in use.

Lighting Controls

The background uplighting on the second and third floors is switched-on manually and automatically switched-off in steps at the end of the day by an ECS Ltd. automatic control system. A lunchtime "OFF" period has proved impracticable in this building owing to the occupancy pattern and the extended restrike times of Metal Halide lamps.

The perimeter lights are also automatically extinguished when daylight levels are sufficient: this normally happens only in summer because the building is now heavily oveshadowed by a new building to the east. Many blinds on the west side are also permanently lowered in order to reduce glare and afternoon solar gains.

Building Team

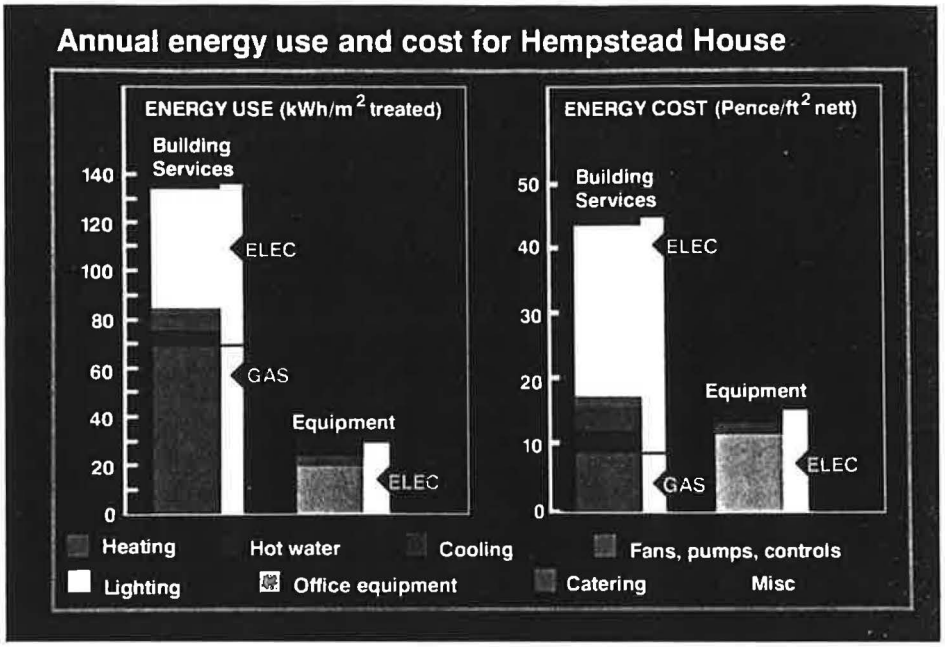
Architects: Fuller Hall & Foulsham
Main Contractor: Blackburn & Co.
Mechanical and Electrical Services Design: Steensen Varming Mulcahy & Partners

Building Details

Speculative office with three tenants
Completed 1982
Floors: 4 office floors + smaller top floor

Gross floor area	2980 m^2 32100 ft^2
Treated floor area	2830 m^2 30500 ft^2
Nett floor area	2440 m^2 26300 ft^2
Typical number of occupants	150
Typical hours of use	9am-8pm weekdays

Evening & Saturday morning use common.



Fabric	U-value (W/m^2K)
Cavity walls	0.6
Double glazing (clear glass)	3.3
Roof	0.6

Heating

Modular cast-iron boilers 4 x 96 kW.
Optimum start/stop and compensation of low temperature hot water circulation.
Perimeter radiators in nine separately-controlled zones.

Hot Water

Local electric storage water heaters with central time-switch control.
6 x 7 litre over sink for catering, cleaning and print room.
8 x 55 litre cistern-fed for toilets.

Ventilation and Air Conditioning

Generally naturally ventilated.
Mechanical ventilation on-demand to plant rooms and print room.
On-demand unit air-conditioning to print room (high equipment and solar gains) and conference room (internal room).
Close control unit air conditioning to first floor tenant's machine room.

Lighting

Good daylight

Fluorescent typically 600 lux	30 W/m^2
Uplighting typically 150-350 lux	18 W/m^2

Analysis of Energy Use and Energy Cost

In 1988 (2038 degree days), 196,000 kWh of gas and 270,000 kWh of electricity were consumed: 69 and 95 kWh/m^2 treated area respectively. The total of 164 kWh/m^2 of treated area is well within the CIBSE Energy Code Part 4's 'good' category of less than 195 kWh/m^2 for an office of this type.

The diagram above gives a detailed breakdown of energy use and cost. Annual total fuel bills were £2200 for gas and £13500 for electricity: 8.4 and 51 p/ft^2 nett respectively.

Heating — 69 kWh/m^2

Heating energy use and cost is very low for a centrally-heated and naturally ventilated building which does not have exceptional thermal insulation levels or advanced plant such as condensing boilers.

Economies have arisen from the modular boiler installation, the separation of space heating and domestic hot water, and in particular the effective zone controls which react independently to user requirements and to local heat gains and losses.

Hot Water — 7 kWh/m^2

Energy use is fairly high for local electric units due to the large **number** of units installed. A more compact arrangement of toilets and kitchens might have permitted a reduction in the number of heaters and the associated standing losses.

Fans, Pumps and Controls — 3 kWh/m^2

Although there are a large number of pumps, their installed power is modest and annual energy use is only slightly more than in a typical centrally heated building.

Air Conditioning — 6 kWh/m^2

Air conditioning energy use is small owing to its limited extent and hours of operation, with two-thirds of the consumption occurring in the tenant's machine room.

Lighting — 49 kWh/m^2

Lighting energy use is only average, many naturally ventilated buildings of this size make better use of natural light. This is partly because to the east, daylight has been restricted by new building at close quarters and to the west many venetian blinds installed for solar protection are often down in order to limit glare and provide privacy. The automatically-controlled metal halide uplighters have also run for longer than anticipated owing to their extended warm-up time: U-tube fluorescent lamps have recently been substituted. However daylight does effectively supplement artificial light in the stairs, waiting areas, and the heavily-glazed fifth floor.

Although the fluorescent ceiling lighting on the first floor uses about 50% more energy than the task/ambient uplighting elsewhere, a modern installation could be designed to be more economical.

Automatic control of the uplighting on the second and third floors saves an estimated 20%, largely from automatic switch-off at the end of the day.

Office Equipment — 21 kWh/m^2

Office equipment energy use is quite high. Although there is only an average of one terminal per 2 persons, there are three separate minicomputer systems (only the largest — using 9 kWh/m^2 — is in an air-conditioned room), including a computer-aided design and drafting system.

Catering — 4 kWh/m^2

Half of this is attributable to an automatic hot drinks machine and the rest to a small, casually-used kitchen and to hot drinks generally.

Miscellaneous — 6 kWh/m^2

This is made up of dye-line printing (2.4 kWh/m^2), telephone switch room (2.3 kWh/m^2), external lighting (1 kWh/m^2) and lift (0.5 kWh/m^2).

User Reactions

The building's energy consumption is generally regarded as satisfactory, and the level of servicing appropriate for the users' needs.

There have been a few complaints of summer overheating due to the generous areas of glazing on the west elevation. Lower peak temperatures could have been achieved if an exposed soffit had been used in place of the suspended ceiling, with better ventilation overnight to ensure the previous day's heat gains, and if the top floor had been less extensively glazed or better solar-protected.

The ambient light level from the uplighting on the second and third floors had dropped considerably from the original design levels, owing to ageing of the lamps and dirt accumulation on lenses, reflectors and particularly ceilings. Most people were still happy with it, and made limited use of their supplementary desk lamps, although a few people had begun to comment. Following the Case Study Survey, the situation has been improved as described later.

General Appraisal

The engineers have succeeded in their general objective of a satisfactory environment with low energy costs in a simple speculative building, insulated only in 1979 Building Regulations Part FF standards except for the double glazing. As tenants they are now reaping the benefit in low energy costs.

The use of ***natural light in the stairs*** and waiting areas is economical and refreshing: such places are so often continuously-lit and give no sense of orientation.

Natural light in the offices has not been as effectively utilised:— the lights usually remain on, even where automatic controls have been fitted. This is by no means an unusual problem in open offices, particularly where blinds need to be lowered for privacy, solar gain and VDU glare control. The long re-strike times of high intensity discharge metal halide, lighting exacerbate the problem: once a light has been switched off it can take 10 minutes or so for it to come on again.

The ***uplighting systems*** have proved satisfactory in terms of appearance and in limiting glare on VDU screens.

Desk lights — although available to all — are only used by the minority in spite of the relatively low light levels in some areas.

Zone control of the heating has been a great success, avoiding the need for the whole building to be heated if one tenant is working overtime, and taking good advantage of solar and internal heat gains.

The electric hot water system is not as economical as might have been hoped: off-peak tariffs have not been used and a large number of heaters were necessary to suit the distribution of facilities. A self-contained gas-fired storage water heater might have been more economic, at least for the toilets and the adjacent kitchens, which are in close proximity.

Main Conclusions

Hempstead House was an early example of high-intensity discharge uplighting in offices. Experience over the past seven years has confirmed its effectiveness, while revealing a faster drop-off in illuminance levels than with conventional fluorescent systems.

Use of daylight has not been as good as expected: a fairly common problem is open offices with windows shaded to limit glare and where the slow warm-up of discharge lighting inhibits switching-off.

Following our survey, each MBI uplighter lamp on the second and third floors has been converted to 6 x 36 watt U-tube fluorescent lamps, giving instant start and a return in illuminance levels to 300-500 lux with greater uniformity and without redecorating the ceilings. A 25% reduction in lighting energy use is expected.

Many well-insulated offices have higher heating costs than predicted because the plant cannot cope efficiently with low heating loads or make effective use of 'free' heat gains. The result is often overheating (with further heat loss from the window-opening) and poor plant efficiency.

The zone control at Hempstead House deals with these problems in an effective way and produces good results. Modern sophistications such as condensing boilers, and automatic isolation of boilers not required for heating duties, could potentially reduce heating costs by a further 20%.

Short Notes on the Measurement of Floor Area

Gross Total building area measured inside external walls.

Nett Gross area less common areas and ancillary spaces. Agent's lettable floor area.

Treated Gross area less plant rooms and other areas (eg stores), not directly heated.

PRECISE DEFINITIONS ARE AVAILABLE ON REQUEST

Design office with uplighting

All case study analyses in this series are based on an apportionment of at least one year's measured fuel consumption and cost. Further breakdown into sub-headings is by a combination of sub-meter readings, on-site measurements and professional judgement. The technique of apportionment is the same for each Case Study and all quoted building areas have been re-measured for the project.

This study has been carried out by the Davis Langdon & Everest Consultancy Group and William Bordass Associates. The cooperation of the owners, designers, managers and the occupants of the case study building is gratefully acknowledged.