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#4553

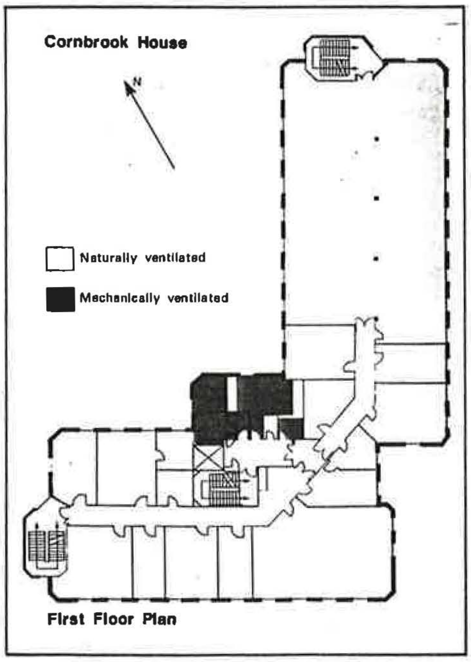
BEST PRACTICE PROGRAMME

Good Practice Case Study 14

ENERGY EFFICIENCY IN OFFICES

A new building designed for minimum heating and cooling energy costs Cornbrook House, Brindley Road, Old Trafford, Manchester

- **Insulation better than 1990 Building Regulations.**
- **Small windows with low emissivity double-glazing to minimise heat gain and loss.**
- **High-efficiency gas-fired condensing boilers.**
- **Self-contained gas-fired domestic hot water system.**
- **Electronic energy management controls.**



The Project

Cornbrook House — the North West Regional headquarters of John Laing Construction Ltd., accommodates a range of activities including design, contracting and computer consultancy. The building was designed by Laing Design to achieve a low energy consumption within the design and cost parameters of a naturally-ventilated speculative office with permanent artificial lighting.

The reinforced-concrete building's three floors are in an L-shape around a central services core, with a smaller fourth floor for plant and storage. Construction is reinforced concrete frame with external walls of brick and block, insulated by partial fill cavity batts. The concrete-tiled trussed-rafter roof has insulation at ceiling level and deep eaves to help protect the building from rain and summer sun.

Wall and roof insulation (U-value 0.4 W/m^{2}K) is not only better than the Building Regulations at the time of construction (1985), but also the new 1990 standard. The aluminium sash windows are small — to limit heat loss and solar heat gains — and double-glazed with low-emissivity glass (U-value 1.9 W/m^{2}K, 2.2 W/m^{2}K including frames). There is secondary glazing on one elevation to limit traffic noise.

The Result

At 70 kWh/m^2, the annual energy consumption for heating is among the lowest of the gas-fired buildings studied. The independent gas-fired hot water system has also proved reliable and efficient.

Monitoring by British Gas has shown that in 1987/88 the condensing boilers had a mean annual efficiency of 80%, (a relatively low value). They suggested that re-commissioning the controls would allow efficiencies to rise towards 90%.

However, since space heating already accounts for less than 20% of Cornbrook House's energy costs, the labour costs of fine-tuning could well exceed the resultant energy cost savings.

Annual lighting energy use (46 kWh/m^2) is about average for the case study buildings: this translates back to an annual cost of 2.5 times as great as the heating.

The building has succeeded in its objective of a good quality environment with a low annual energy use (totalling 155 kWh/m^2 — 20% below the CIBSE Energy Code Part 4's 'good' level) but also demonstrates that with the low heating costs and thermal stability which good insulation and efficient plant bring, other areas of energy consumption and cost, particularly lighting, come into sharper focus.

BEST PRACTICE PROGRAMME

Energy Efficiency Office
DEPARTMENT OF ENERGY

C1/Sfb 1976 32 R3 W8 Y7

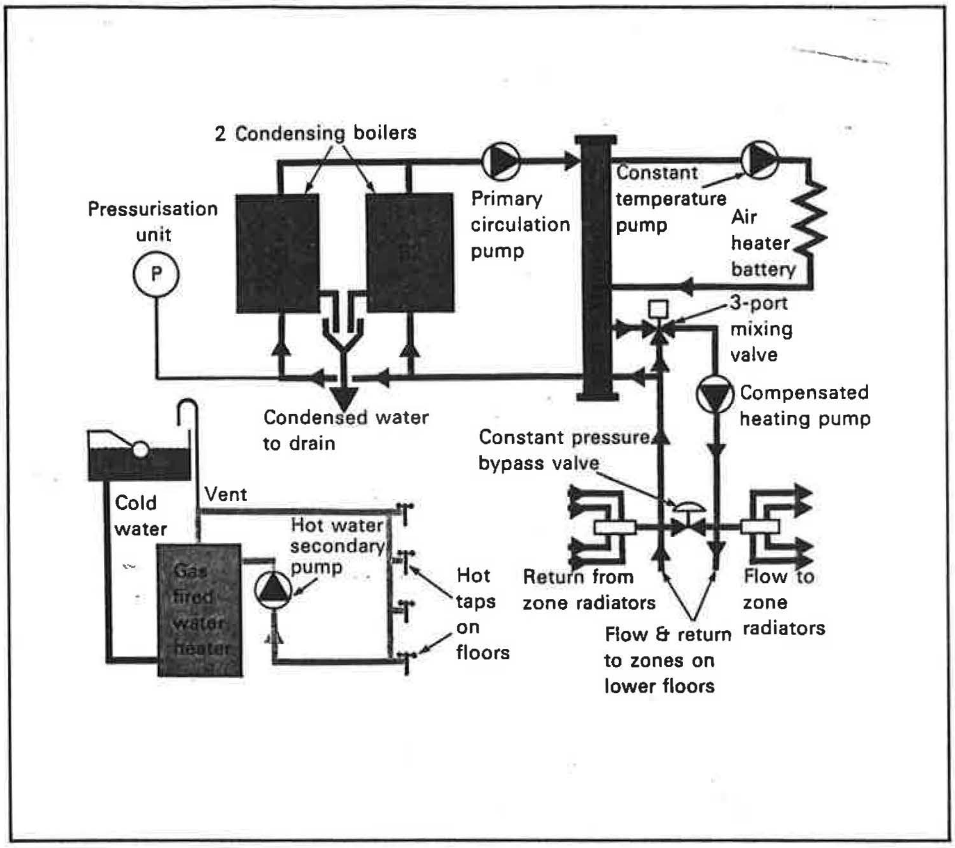
Heating System

Heating is by perimeter high-output convector radiators on an outside temperature-compensated circuit. These are fed by low-temperature hot water (LTHW) from two floor-standing cast-iron gas-fired Seagold condensing boilers in the roof plant room. Fans in the condensing boilers draw the flue gases through a second heat exchanger which recovers additional heat and, for part of the operating period, condenses water vapour formed in the combustion process. In a well-designed system, this typically raises seasonal efficiences by 10-20%.

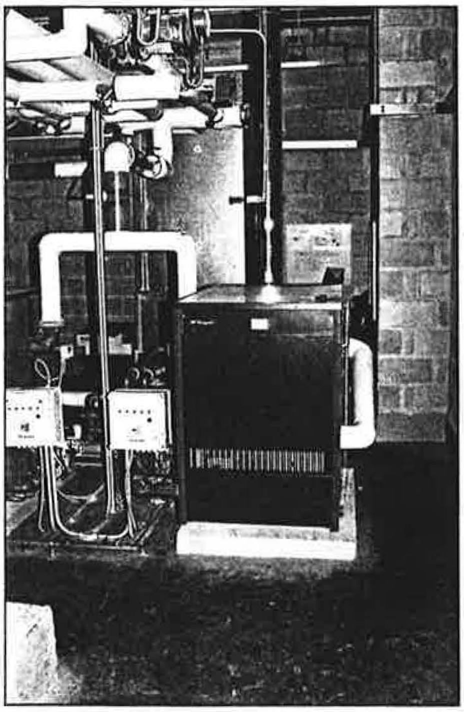
Unusually for a commercial building, microbore pipework is used for final LTHW distribution from manifolds at high level in the toilets, via the ceiling space, to perimeter radiators in the wings.

The efficiency of a condensing boiler increases as the return water temperature drops. The system was therefore designed to maintain internal comfort conditions at an external temperature of −3°C with a flow temperature of 65°C and a return temperature of 40°C (more conventional UK temperatures are 80/70°C). Current design guidance suggests that good performance can be obtained at conventional design flow temperatures, provided that boiler flow temperature is directly weather compensated.

Pressure differential valves on each floor circuit allow individual floors, or parts of floors, to be isolated without disturbing the hydraulic balance of the overall system.



Heating system schematic



Boiler plant

Mechanical Ventilation Systems

The toilets are mechanically-ventilated with a tempered air supply and common extract. Separate local extract systems are also installed for the conference rooms, print room, and cleaners' rooms.

Heating and Ventilation Controls

A single multifunctional Honeywell Excel electronic controller in the boiler room provides a 7-day time programme, with optimum start, stop (with pump run-on). It also provides external temperature-linked compensation for the perimeter heating, plus fixed time and temperature control for the supply air for the toilet ventilation system.

The Excel unit also controls the boiler plant: electrically and mechanically isolating the second boiler when not required, compensating the LTHW flow temperature in accordance with outside temperatures, and keeping the return temperature above the recommended minimum.

All radiators have thermostatic valves to permit individual room temperature control.

Domestic Hot Water

Domestic hot water is provided from a self-contained gas-fired storage water heater in the plant room, with a pumped secondary circulation loop to taps.

Lighting

Recessed twin-tube ceiling-mounted fluorescent fittings with specular reflectors and low-brightness louvres are used generally in offices, corridors and toilets. Typical illuminance levels are 400-500 lux for an installed power of 14 Watts per square metre.

Miniature fluorescent lights are used on the stairs, and there is a small amount of tungsten and tungsten-halogen accent lighting in the reception and entrance areas only.

Lights in cellular offices are locally-switched while those in open offices are switched in groups from the door. Owing to the small window areas and internal stairs and passages, most of the lights are on permanently during occupancy hours.

Building Team

Architects and Engineers	Laing Design
Builder	John Laing plc

Building Details

Regional building contractor's office to speculative standard. Completed 1985
Floors: 3 office floors + smaller top floor with plant and storage

Gross floor area	2500 m² 27000 ft²
Treated floor area	2240 m² 24100 ft²
Nett floor area	1990 m² 21400 ft²
Typical number of occupants	160
Typical hours of use	8.30am-5pm

Evening & Saturday morning use common.

Fabric	U-value (W/m²K)
Cavity walls	0.4
Double glazing (low emissivity glass)	2.2
Roof	0.4

Heating

Cast-iron atmospheric gas condensing boilers 2 x 96 kW for central heating only.

Optimum start/stop and compensation of low temperature hot water circulation.
Design flow and return temperatures 65/40°C.

Electronic energy management controls using a Honeywell Excel programmable multifunctional controller.

Hot Water

Separate gas-fired storage water heater, 62 kW input, with compact insulated secondary circulation loop to WCs and sinks.

Ventilation and Air Conditioning

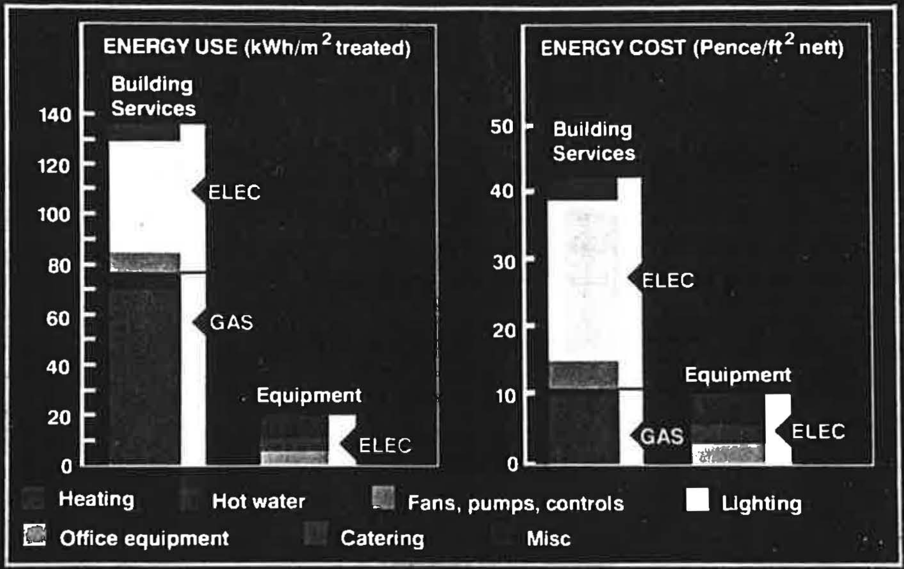
Generally naturally ventilated, with tempered mechanical ventilation to toilets. Extract ventilation only to conference rooms, print rooms and cleaners' stores.

Two local manually operated packaged air-conditioners in electronic equipment rooms for emergency summer use only.

Lighting

Limited daylight through small windows.
Fluorescent typically 450 lux 14 W/m²
Manual light switching only.

Annual energy use and cost for Cornbrook House



Analysis of Energy Use and Energy Cost

From October 1987 to September 1988 (2243 degree days) 172,000 kWh of gas and 176,000 kWh of electricity were consumed. The total of 155 kWh/m² of treated area is well within the CIBSE Energy Code Part 4's 'good' category of less than 195 kWh/m² for an office of this type.

The diagram above gives a detailed breakdown of energy use and cost. Annual fuel bills were £2200 for gas and £8900 for electricity: 10.5 pence and 41.5 pence/ft² nett respectively.

■ Heating 70 kWh/m²

The high insulation levels and condensing boiler plant have given a very low heating energy use, in spite of the fairly high internal temperatures at which the occupants prefer to set their thermostatic radiator valves.

The condensing boilers have been monitored by British Gas, who report a drop in mean annual efficiency from nearly 90% in 1986-87 to just under 80% in 1987-88. The problem appears to have originated when the electronic controls were corrupted by electrical interference. This took a long time to put right because suitable skilled manpower does not appear to have been readily available to correct it. Even after the electronic controls had been reset, boiler operation has no longer been optimal.

If carefully re-commissioned, it is likely that annual heating energy consumption could fall below 60 kWh/m².

■ Hot Water 7 kWh/m²

The separate and compact hot water system has operated effectively and economically.

■ Fans, Pumps & Controls 7 kWh/m²

Energy consumption is average for the size of building and the extent of systems installed.

□ Lighting 46 kWh/m²

Energy use is only average. Although the installed power is moderate, most lights are on throughout the working day. This is to compensate for the low natural light levels from the small windows, (chosen to minimise heat loss and gain), and to service the internal stairs, corridors (with rather high illuminance levels) and toilets. Many naturally-ventilated buildings of this size and with cellular offices make better use of natural light.

■ Office Equipment 6 kWh/m²

This figure is largely attributable to desk-top computer and word processing equipment (approximately one PC or terminal per 3 persons), including one minicomputer.

■ Catering 5 kWh/m²

This is almost entirely attributable to three hot drinks machines which need to run for 24 hours per day to operate reliably (otherwise the powders congeal).

■ Miscellaneous 14 kWh/m²

This is made up of external lighting and signs (5 kWh/m²), summertime air conditioning unit for data processing room, (1 kWh/m²), telephone exchange and modem rack (4 kWh/m²), print room (3 kWh/m²) lift and electric hand dryers.

CORNBROOK HOUSE

Open plan office

Main Conclusions

Cornbrook House demonstrates that with modern technology and insulation standards a simple office building can have heating costs of under 10 pence per square foot of nett lettable area. At this stage heating fuel costs become such a small proportion of the total that it becomes important to avoid unnecessary complication — (which may add to capital, maintenance or management costs), and to look critically at other energy uses, particularly lighting, before attempting to improve heating performance still further.

Should Cornbrook House have made so little use of daylight when lighting costs 2.5 times as much as heating? Certainly, in many of the large case study offices, lights do tend to be left on regardless, but in some smaller ones of a similar size to Cornbrook House, daylight has been more effectively utilised, particularly in cellular offices.

Laings have now designed a similar office at Bradford for the Yorkshire Water Authority, technically similar to Cornbrook House but with larger windows. It will be interesting to see whether or not it has lower overall energy costs.

User Reactions

The building is generally regarded as satisfactory. A few occupants commented on insufficient ventilation, possibly a reaction to the small windows, low natural light level, and fairly warm environment. The designers would like to have included background mechanical ventilation but it was too expensive.

Single cell office

General Appraisal

The designers have succeeded in creating a well-insulated building with annual heating and hot water costs of under £1.00 per square metre of treated area (or £2000 per annum). This means that further fine-tuning of the controls would not be cost-effective: a single engineer's visit (required at least annually), might well cost as much as the whole year's potential energy cost savings.

The inability of the multifunctional electronic controller to achieve its full potential in a relatively small building such as this has highlighted the need to keep things simple. Straightforward, standard, more 'user friendly' controls might have been at least as effective as the more complex system, and faults would have been more easily diagnosed.

In choosing small window areas, the designers took the view that since the lights in offices tend to be on most of the time anyway, it would be best to accept the fact, keep the windows small to conserve heat and reduce solar gains, and to make the lights as efficient as possible. At 14 W/m^2, the installed lighting load is fairly low, although using the latest technology high-frequency lighting with high efficiency reflectors (not readily available at the time Cornbrook House was designed) installed loads of under 10 W/m^2 would now be achievable. The corridors through the offices are also lit to the same standards as the workspaces, while an adequate standard would have been obtained with half the number of tubes in operation.

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.

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.

Office Case Studies are a product of the Energy Efficiency in Offices project, funded by the Department of Energy through the Building Research Energy Conservation Support Unit (BRECSU). This study has been carried out by 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.

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