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Air-conditioning and energy efficient buildings in the UK

by A. Field, BRECSU, United Kingdom

Air conditioning has become much more widely used in commercial buildings in the UK over the last few years. Use of air-conditioning inevitably imposes demands for energy to run fans and pumps and to provide refrigeration and humidity control. Although air-conditioned and naturally ventilated buildings in principle require the same levels of fresh air, in practice air-conditioned buildings usually have higher air change rates and consequently a greater heating demand in winter. In addition, air-conditioned buildings tend to have deep floor plans, which lead to increased use of artificial lighting.

As part of the UK's Energy Efficiency Office's Best Practice programme, BRECSU has produced information on energy use in office buildings. Figure 1 shows typical annual energy costs at 1991 prices in four types of offices:

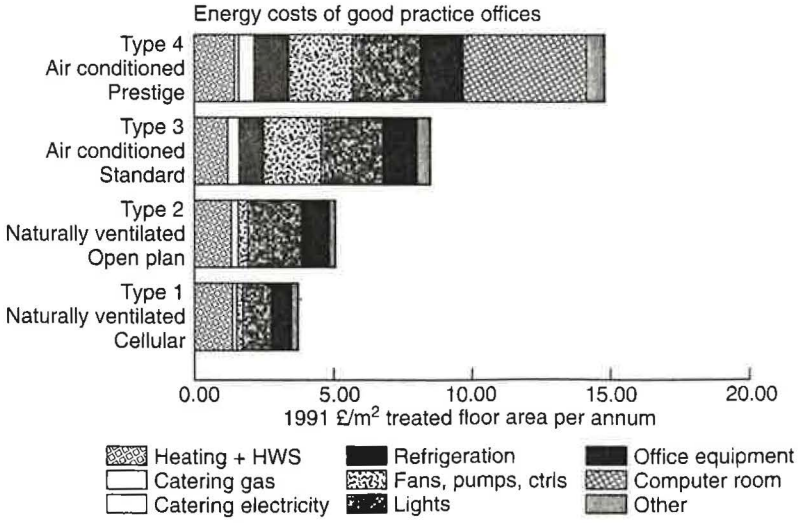
Type 1: Naturally ventilated, largely cellular
Type 2: Naturally ventilated, largely open plan
Type 3: Air-conditioned standard, largely open plan
Type 4: Prestige air-conditioned with computer suite, restaurant etc.

In the type 3 standard air-conditioned office, typical annual energy costs for refrigeration plus fans, pumps and controls amount to about GBP 5.20/m^3 treated floor area, out of total energy costs of about GBP 14/m^2. This compares with typical annual energy costs in the type 2 naturally ventilated open plan office of about GBP 7.90/m^2 (heating energy use is normalised for temperature using a basis of 2462 degree-days in all figures).

It is therefore apparent that substantial energy savings can be made by avoiding air-conditioning altogether where possible. In some cases, it may be possible to meet the required environmental requirements in other ways. For example, it is now possible to design non-air-conditioned offices to be more comfortable than their forebears, particularly the lightweight offices which were common in the UK in the 1960s. Designers can use more efficient lighting, better protection from solar heat gains, and sometimes background mechanical ventilation and thermal storage in the building fabric. Heat gains from office equipment may also be dealt with by locating shared equipment, such as photocopiers, vending machines, printers and communications equipment, in separately ventilated or cooled areas.

However, despite the higher capital, energy and maintenance costs, air-conditioning is often specified for new buildings and refurbishment without pause to think about the cost consequences. Reasons include: client demand, external noise and pollution, high internal gains, hotter summers, improved comfort, organisational prestige, greater flexibility, and institutional requirements. As a result of these factors, air-conditioned buildings command

Figure 1: Energy cost of good practice offices.



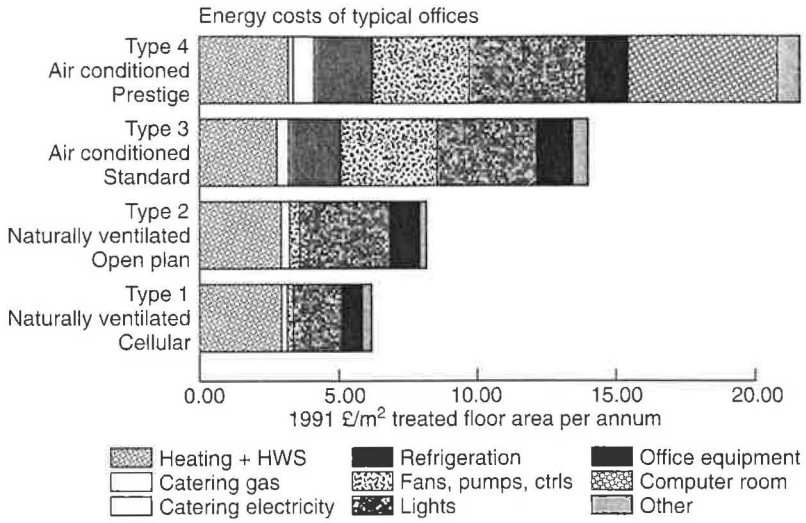


Figure 2: Energy cost of typical offices.

significantly higher rent fees than other buildings. For such buildings, the challenge for designers is to meet the specified requirements with systems that avoid energy waste.

Good practice air-conditioned offices

In addition to data on typical levels of energy use in offices, BRECSU has produced yardstick figures for good practice, shown in Figure 2. The good practice level of annual energy cost for the type 3 standard air-conditioned office is about GBP 8.50/m³ treated floor area, almost 40% less than for typical offices of this type. This level of cost corresponds to heating fuel use of 100 kWh/m² and electricity use of 132 kWh/m². Offices operating at this good practice level cost little more to run than typical open plan naturally ventilated offices, for which an average energy cost is about GBP 8.00/m² (Figure 1).

One fully air-conditioned office building which performs even better than this yardstick level is 1 Bridewell Street in Bristol (Figure 3), which was studied by BRECSU.

Here, energy use in the analysis year (1799 degree-days) was 53 kWh/m² for gas and 86 kWh/m² for electricity (Figure 4). The building is on a city centre site and does not have any remarkable energy saving architectural or engineering features in particular. Instead, a low level of energy consumption has been achieved by a combination of effective design and management:

- The building envelope has a 175 mm dense concrete wall as its main enclosure, with a 'rain screen' cladding system which is open-jointed and fully ventilated so that any solar heat picked up by the panels is dissipated and little is transmitted to the interior of the building. The masonry wall also provides a stabilising element to the internal thermal environment of the building. However, insulation standards are not exceptional (the wall U-value is 0.6 W/m²K).
- The building services are carefully managed by the occupants, with the aid of a building energy management system (BEMS).
- The office air-conditioning is based on a conventional variable air volume (VAV) system, augmented by heating only fan-coil units at the perimeter. The main VAV system operates at low pressures (450 Pa supply, 100 Pa extract), leading to low energy consumption by fans. All systems are well controlled, and heating and cooling pumps are not

Figure 3: The Bridewell Street Offices.

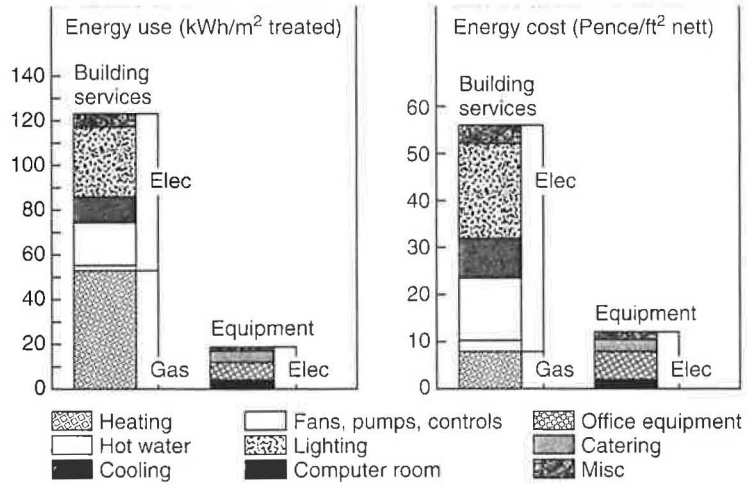


Figure 4: Annual energy use and cost of the Bridewell Street Offices.

allowed to be operated simultaneously.

- Heating is provided by two gas-fired boilers controlled by the BEMS. The boilers are switched off entirely in summer as there is no reheat load and domestic hot water is provided by local electric water heaters.

- High efficiency fluorescent lighting with good reflectors and high frequency electronic control gear is used in the offices. The lights are well controlled using a combination of techniques: occupancy sensors in circulation areas; local switching by hand-held infra-red controllers in offices plus automatic switching off at the end of working hours; solar control of perimeter lights according to daylight levels; and reduced lighting levels for cleaners' schedules.

The result has been that demands on the air-conditioning system have been minimised as much as possible, and the system meets the resulting loads efficiently. This is achieved without any particular innovation, but through sensible use of available technology, together with a high standard of management.

Natural ventilation or air-conditioning?

People usually see a straight choice between natural ventilation and full air-conditioning and many now choose the latter. However, individual occupants seem to react against deep, mechanically controlled spaces, and may prefer environments which offer more personal control and access to natural light and ventilation.

While air-conditioning may be essential on noisy or polluted sites, and with high equipment loads (as in financial trading organisations), the range of office studied by BRECSU includes several naturally ventilated buildings which perform satisfactorily with as much information technology as their air-conditioned counterparts.

A possible middle way

It could be unwise to specify which office cannot readily accommodate some air-conditioning, as future cooling loads and requirements may grow. One possibility is a "mixed mode" design. Some of the EEO's Good Practice Case Studies of energy efficient offices indicate possible directions:

- Hereford and Worcester County HQ, a 23,600 m² gross floor area headquarters office building for a local authority where the offices have openable windows and HVAC systems which provide heating, ventilation and cooling; operating modes vary with season.

- NFU Mutual and Avon Group Head Office, a 14,610 m² gross floor area head office building for an insurance company, which uses background mechanical ventilation together with openable windows, and some local air-conditioning.

- Refuge House, a 17,820 m² gross floor area insurance company head office where both natural ventilation and air-conditioning (through under-floor fan-coil units) are available throughout, and are selected to choice.

In each of these buildings, a high standard of internal environment is achieved without the need for air-conditioning to be operating throughout the building at all times of the year.

For more information please contact: BRECSU Enquiries Bureau, Building Research Establishment, Garston, Watford WD2 7JR, United Kingdom.
Tel.: +44-(0)923-664258;
Fax: +44-(0)923-664097.

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