Energy efficient offices: case histories

In the UK approximately £900 million/y is spent on energy in office buildings. Savings of £280 million/y are possible through cost effective improvements to design and management of buildings and their services. *Deborah Brownhill* reports.

To achieve the above savings requires concerted effort at all stages of building design and operation. Until recently however, designers have had the almost impossible task of making decisions about fabric and services with only an intuitive feel for how their decisions really affect the bottom line, ie the energy bill. A number are to be congratulated for achieving so much under these circumstances.

To help take some of the guesswork out of the design, the Building Research Energy Conservation Support Unit (BRECSU) has been collecting information for the Energy Efficiency Office on a range of energy efficient office buildings. These buildings are featured as a series of good practice case studies as part of the EEO's Best Practice programme. This article presents the initial findings from this project and draws some early conclusions from the data.

The aim of the case studies is to cover all common types of office building, both new and refurbished, and to show that with the correct approach to design, specification and management it is possible to:

□ build and refurbish all types of offices to high standards of energy efficiency;

□ satisfy different levels of user requirements and environmental standards;

□ stay within normal capital budgets.

Figure 1 shows the energy consumption/m^2 of treated area of the BRESCU portfolio of case study office buildings. The consumption is broken down into separate end uses.

The first thing to note from this histogram is that the energy use for the heating and hot water forms a major proportion of the total for most buildings. However, this situation changes if the energy consumption is converted into cost, as shown in figure 2. Heating and hot water shrink right back as a percentage of the energy bill due to the difference in price between fossil fuels and on-peak electricity.

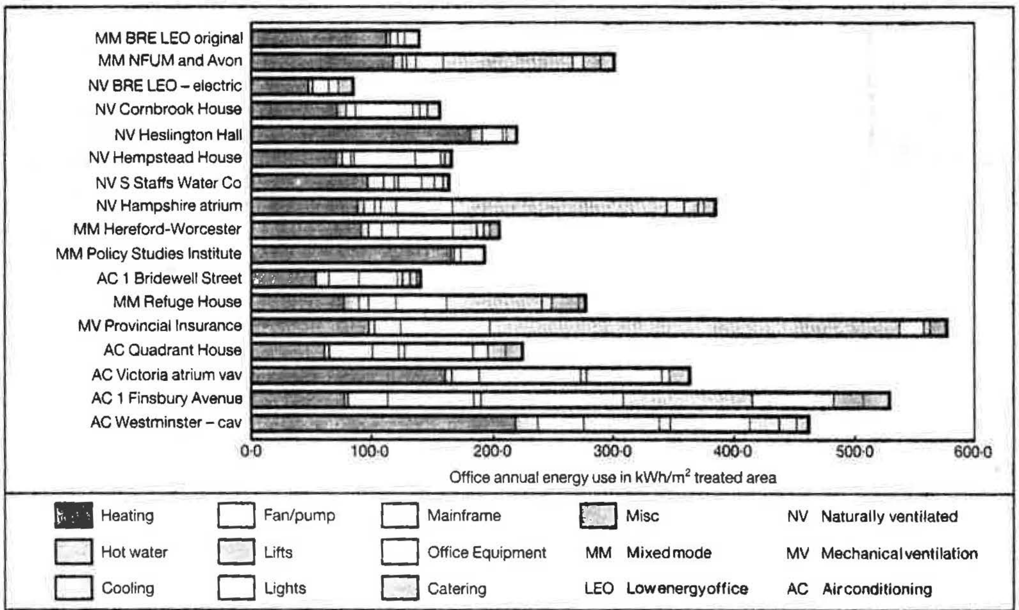
Therefore, particulary in new buildings with reasonably well insulated fabric, it is essential to give as much thought to the design of the other energy-using services, eg lighting, as to the building's heat loss, although effective design and control of heating systems remains important.

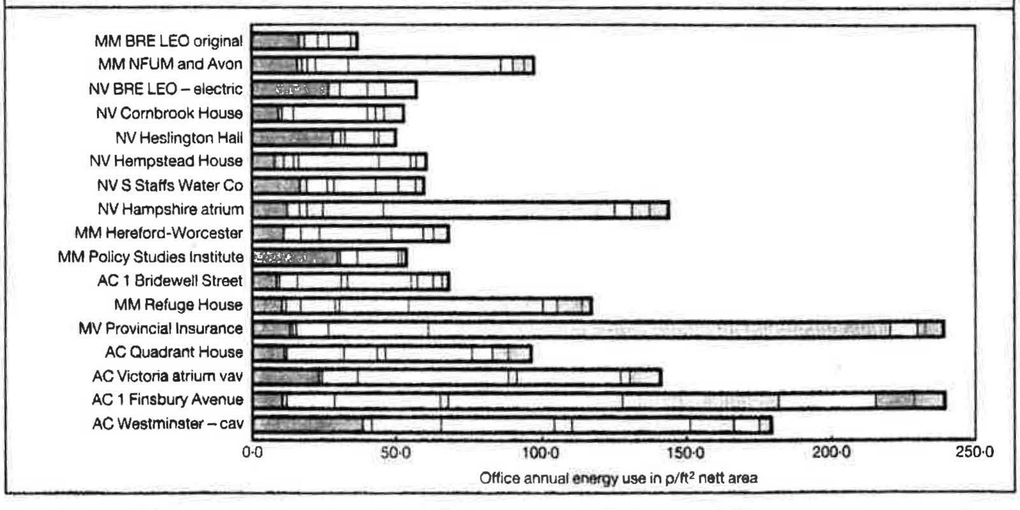
A second important fact revealed by these histograms is that the energy costs for some office buildings can be completely dominated by the activities going on inside, rather than the design of the building shell. Most significantly, the energy used by mainframe computers and their associated cooling can be the largest and most expensive user of the energy in offices.

Often in our search for energy efficient office buildings one or two areas let down an otherwise well-designed and operated building. From the cost histogram it can be seen that in many offices the energy bill for lighting exceeds the energy bill for heating. For example at Cornbrook House the designers strove very hard to limit heat loss and gain, and keep the window area particularly small. Consequently it is necessary for the lights to be left on for most of the time; the cost breakdown reveals that lighting costs nearly three times as much as heating. The overall energy consumption and cost for this building is still extremely low however, and the decision to keep the windows small was a deliberate one, as the designers considered that the lights would probably be on for most of the time anyway.

Other case study buildings of similar layout to Cornbrook make good use of daylight. They usually have a definite daylighting strategy and well controlled artificial lighting or predominantly cellular offices. They are either narrow plan or have courtyards to bring light into the centre of the building.

One innovative way of using daylight deep in the internal space is adopted at the South Staffordshire Water Company





Top, figure 1: Office annual energy consumption/m^2 of treated area. ***Above, figure 2:*** The same energy consumption converted into costs.

Headquarters in Walsall. This building has reflective light shelves set near the top of the windows to bounce light into the ceiling of the office and back down onto the floor inside. The light shelves help to create an even natural light distribution throughout the office in all daylight conditions, and in strong direct sunlight can enable the sunbeams to penetrate deeper into the building. However, tall windows and high ceilings are necessary to accomodate them and this building has a square plan with facades facing sw, se, nw, ne; this ensures each facade benefits from some direct sunlight.

The result is a bright and airy workspace right into the centre of the building. With hindsight some additional blinds would have prevented the occurance of occasional glare problems.

Air-conditioning typically doubles building services energy costs. The diagram shows energy used for cooling and energy used by the fans and pumps. In most cases the energy used by the fans and pumps is much greater than the energy used for refrigeration. Small duct sizes and high pressures exacerbate this natural effect for both variable and constant volume systems.

The only fully air-conditioned office building that does not reflect this general trend is Quadrant House in Surrey. Quadrant has a Versatemp air conditioning system employing a water ring main and a series of heat pumps for separate rooms. By careful management this system copes extremely efficiently with the simultaneous demand for heating and cooling. This was not always so: before improved energy management and a new bems, air conditioning costs were twice as high as they are now.

Since the majority of the energy used by the air conditioning is attributable to fans and pumps, it shows that the typical refrigeration requirements even in quite sophisticated deep plan offices can be quite low. Often office equipment heat gains are greatly overestimated and lead to oversizing of cooling plant. This is due in part to manufacturer's labelling of machines being taken by the client or the service engineer and used (with a safety factor added) to design the cooling system. In practice BRECSU and others are discovering that most office equipment uses only a small proportion of the electricity stated on the nameplate even when working flat out.

The energy used by office equipment is illustrated on the histograms to be quite small, a few percent of overall energy in most cases, even though several of the offices have high levels of IT equipment ie one personal computer or terminal per person).

BRECSU will be looking further into the energy use of office equipment and appropriate ways of providing cooling for main frame computers, and will be producing guidance on these as part of the EEO's Best Practice programme.

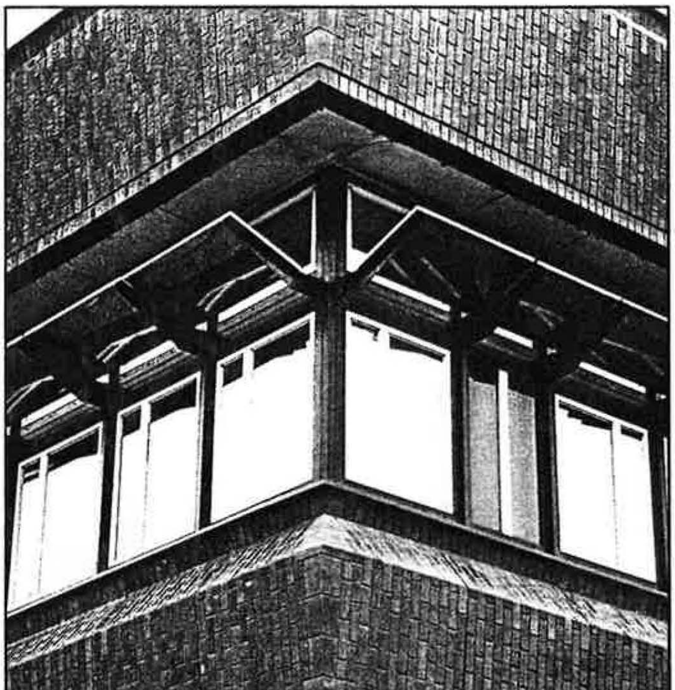
Given that the internal gains in an office are normally much lower than assumed for the services design, the potential for servicing many office buildings without resorting to full air conditioning is greater than generally believed. Indeed an overview of the case studies suggests that there is an interesting middle ground between the traditional options of naturally-ventilated and fully air-conditioned buildings.

Buildings occupying the middle ground have been called "mixed mode" buildings, ie the fabric has been designed with effective passive systems — natural light, natural ventilation, direct solar gain with summer shading, good thermal performance — plus supplementary mechanical ventilation and cooling where necessary. Where circumstances allow, these buildings can offer a high quality environment with capital and energy costs often significantly below those of fully air-conditioned offices.

Refuge Assurance demonstrates an advanced form of this type of building. Designed to act as a naturally ventilated building, ie protected against solar gain and avoiding deep plan and sealed windows, the property also has an air-conditioning system. The occupants therefore have the choice of when and where to operate the air-conditioning. The company also has an area designed for a computer suite that it wishes to air-condition all the time, and this arrangement then allows them the flexibility to accomodate this.

This idea is already being adopted in speculatively built offices as it allows the developer to charge the high rental associated with air-conditioned buildings while giving the tenant greater choice.

To provide the flexibility described in the example above requires several stages of design input. Firstly the building must be designed to act as robustly as possible without air-conditioning. Then the servicing strategy must be carefully thought out. For example, a series of separate air-conditioning systems to cover different zones is probably a logical option, ie there is no point having a huge central plant that does not work efficiently at low loads. Lastly it is important to educate the tenant on the different operational modes of the building. He in turn may wish to educate the workforce, for example to keep their windows closed in hot weather when the air-conditioning is on!



Above: South Staffordshire Water Company Headquarters.

The BRECSU portfolio of case studies will eventually cover all common types of office building, eg new and refurbished, different ages and regions, naturally ventilated, mixed mode and air-conditioned offices, owner occupied, multi-tenanted or speculative, with different heating, lighting and air-conditioning systems. The first series of ten case studies has begun publication, with another five case studies identified to follow on.

The general criterion satisfied by these buildings is that the energy use for building services must be less than 250 kWh/m^2 of treated floor area[1]. Most achieve less than 200 kWh/m^2, and the buildings chosen have had their energy use recorded for at least one year.

The energy used for each fuel type has been measured separately and a further breakdown into heating, hot water services, air conditioning, lighting etc is determined where possible. In areas of scant or doubtful information (particularly energy consumption by office machines), some basic monitoring was carried out.

We would be interested to hear from any readers who believe they have a building comparable with the best in our portfolio. For further information and your free copies of the case studies please contact: Enquiries Bureau, BRECSU, BRE, Garston, Watford, WD2 7JR, Tel 0923 664258.

[1] Notes on Floor Area
Reported building floor areas were often found to be inconsistent, so nett, gross and treated floor areas were measured by independent chartered surveyors. No exact definition of "treated floor area" (the most relevant when assessing energy consumption) could be found, so one has been developed for these case studies and it is hoped this will become the standard. Short definitions are:
☐ 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.