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Energy efficiency in offices

By Deborah Brownhill

Offices comprise a broad range of building types, from single storey naturally ventilated buildings with little more complexity than a normal house, to highly sophisticated air conditioned enclosures where even the lights are automatically controlled.

In the UK approx £900 million a year is spent on energy in office buildings. This figure is rising each year as the sector grows and becomes more sophisticated. Savings of £280 million a year are possible through cost effective improvements to building design, plant, and energy management.

To highlight how these savings can be achieved, BRECSU (Building Research Energy Conservation Support Unit) has been collecting information for the Energy Efficiency Office on exemplar energy efficient office buildings. These will be described in a series of *Good Practice Case Studies* to be published as part of the Energy Efficiency Office's *Best Practice* programme. The first five of these case studies are in the process of being printed. This article highlights the methodology adopted in the production of the case studies, and previews the findings of the first one.

The case studies show that with the correct approach to design and specification, it is possible:

- to build and refurbish all types of offices to high standards of energy efficiency
- to satisfy different levels of user requirements and environmental standards
- to stay within normal capital budgets.

The Policy Studies Institute where energy efficient refurbishment was carried out on a tight budget

Offices are often ranked for energy efficiency in terms of their overall energy use per unit area. Unfortunately this ignores differences in function, servicing level, fuel cost, particularly the relatively high cost of on peak electricity, and intensity of occupation. Air-conditioned buildings are usually allowed higher energy cost targets than naturally ventilated ones. However, it is sensible to apply this higher target only to buildings where it is not possible to deal with the heat gains in another way. Some of the case studies show successful, sophisticated, modern head offices that have dealt with significant heat gains without resorting to full air-conditioning.

The case studies therefore describe

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Not only a very welcome dram, but a more energy efficient one as well

the biodegradable solids and converts them to biogas, a mixture of carbon dioxide and methane. As a result, not only does pot-ale become an intermediate effluent that can be purified to river discharge standards using conventional treatment technology, but the gas produced can be used within the treatment plant to reduce the consumption of fossil fuels.

A number of pilot-scale trials have been carried out at Macallan's Distillery and also by Biomechanics and the University of Newcastle. These confirm that anaerobic digestion is very appropriate for the treatment of pot-ale. However, in order to meet the high standards required for discharge into UK rivers, the design and operation of each treatment unit will need to concentrate first on the removal of any dead yeast prior to digestion and then on the removal of the suspended solids produced by the biological fermentations.

Activated sludge treatment is the most appropriate method of secondary treatment. It offers the possibility of achieving effluent polishing, nitrification and denitrification all in the same unit, but it is very dependent on receiving an intermediate effluent with a low level of suspended solids.

If the overall performance targets of 99.95 per cent removal of biochemical oxygen demand (BOD), 99 per cent removal of ammonia and appropriate levels of surplus sludge production can be achieved, then anaerobic digestion could well provide an effective and environmentally acceptable means of disposal for surplus pot-ale.

Readers interested in learning more about this subject should contact Philip Mann, an ETSU project officer, on 0235 433528.

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each building and its services in detail, and assign energy consumption and cost to a range of different end uses such as heating and lighting. This affords some interesting information. For example, it is possible for a building with low overall energy consumption and efficient heating to have high lighting costs. Other buildings can have energy efficient building services but suffer high energy costs originating in their computer rooms. Some companies manage to re-use the waste heat from their computer rooms to heat other parts of the building. By combining the good features of a number of case studies, the new buildings of the future can be designed with considerably lower energy costs than the case study buildings of today.

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 this middle ground have been called mixed mode buildings, 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 when and where necessary. Where circumstances allow, these buildings can offer a good quality environment with capital and energy costs significantly below those of fully air-conditioned offices.

To date, a shortlist of 10 buildings has been selected for case studies. The aim of the portfolio of case studies is to cover all common types of office building – new and refurbished, different ages and regions, naturally ventilated, mixed mode and air conditioned offices, different heating, lighting and air conditioning systems.

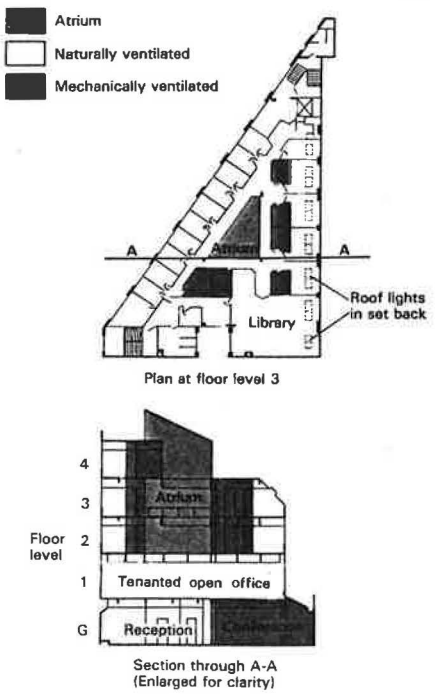

Figure 1 – plan and elevation

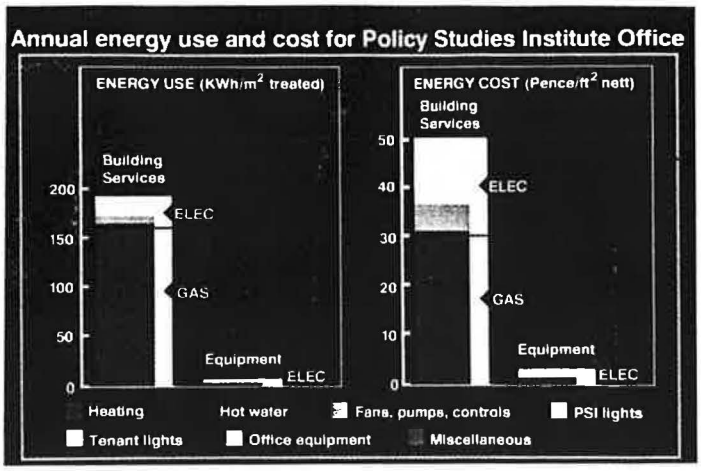

Figure 2 – energy use and cost

All 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.

Reported building floor areas were often found to be inconsistent, so net, 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.

The first office building in the series of case studies is the Policy Studies Institute (PSI) building, an example of an energy efficient refurbishment within a tight capital budget.

An office building in poor condition (originally a 1920's factory) was purchased for low-cost conversion into office space with library, conference rooms, meeting rooms and kitchen. The building has an unusual triangular floor plan (see Figure 1) which presented a major design challenge, to reconcile the requirement for large numbers of cellular offices with the windowless space in the centre of the building, whilst avoiding the need for expensive air conditioning.

The solution was to pierce a small atrium through the top three floors. This has a number of benefits:

- it brings light and air into the centre of the building
- it expands the perimeter for cellular offices
- it avoids the need for air conditioning
- it collects solar heat

This design option allowed many of the rooms to be naturally ventilated, with mechanical ventilation to the atrium and surrounding offices only.

The result is a good example of a '**mixed mode**' office building with the following features:

- new smaller double glazed windows to improve thermal performance
- good daylight to give low lighting costs
- air quality sensors to regulate fresh air intake
- solar energy collection distributed by atrium exhaust air.

A detailed breakdown of delivered energy use and cost is shown in Figure 2. From this it can be seen that:

- **energy use for heating is predominant**, because the solid wall construction of the building made wall insulation prohibitively expensive, and initial capital restraints meant that the original cast iron boilers were retained and overhauled rather than replaced with new high efficiency ones
- **lighting and electricity consumption are particularly low**, due to the fact that the PSI building makes good use of natural daylight, and has little sophisticated office equipment.

Most of the other case study buildings have much higher standards of insulation. For these buildings, also with low overall energy consumption, **lighting often uses as much energy as heating**, and costs typically about three times as much. Lighting therefore represents an opportunity for significant energy savings in highly insulated offices.

Just as the PSI design team has worked within the constraints of tight budgets, awkward form and old construction to produce a highly innovative energy efficient solution, so also have the designers of the other case study buildings. In its own way, each building is an example of good energy conscious design.

For further information or copies of the case studies please contact: Enquiries Bureau BRECSU, BRE, Garston, Watford WD2 7JR. Tel 0923 664258 (63)