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BEST PRACTICE PROGRAMME

Good Practice Case Study 21

ENERGY EFFICIENCY IN OFFICES

One Bridewell Street, Bristol

A new high quality air conditioned office with low energy costs

- **Low fan energy consumption for an air conditioned office.**
- **High frequency lighting with effective central and local control.**
- **Naturally lit corner atrium.**
- **Effective energy management aided by electronic BEMS.**

The Project

One Bridewell Street, in the centre of Bristol, was developed by MEPC to be the accountants Arthur Young's South-West regional office.

The building was to have a contemporary, high profile image. Developer's and occupier's requirements, although not specific about energy efficiency, included high quality and low running costs.

The brief also required flexibility in occupancy and operation, both to support increasing densities of desk-top information systems, and to permit any parts of the building not required by Arthur Young to be sub-let.

The six-storey building, completed in 1987, includes a full height corner atrium facing south-east and a small 2-storey wing accessible both from the main offices and separately.

Arthur Young initially occupied the first and second floors, with tenants on the top three floors. Their merger with Ernst & Whinney in October 1989 confirmed the flexibility of the building, with their occupancy first increasing from 115 to 165 and subsequently expanding onto part of the third and all the fourth floor.

The shared ground floor contains car parking, minicomputer room, storage and maintenance areas, and a small gym/fitness facility.

The Result

The building provides a high quality of environment, flexibility of operation and an attractive and bright appearance. It has been commended by the RIBA and was joint runner-up for the Institute of Administrative Management's (IAM) Office of the Year Award 1989.

The atrium provides an impressive entrance with reception at ground level and circulation on the floors above. Temperatures in the atrium are not tightly controlled and daylight is good, giving a possible nett benefit in energy terms — however this aspect has not been specifically monitored.

Air conditioning is conventional VAV, but well designed for low fan power and fully zoned with computerised BEMS controls to allow a close match to the varying needs of the occupants. Similarly, lighting is high efficiency under effective central and local control. Ernst & Young also manage the whole building very effectively, helping them to win the IAM Facilities Management Award 1989. The resulting good design and good management has led to unusually low energy costs for an office of this type, no greater than for many naturally ventilated offices.

At 139 kWh/m^2 of treated area, energy use is very low for an air conditioned building, approaching half of the CIBSE Energy Code part 4's "good" level.

Energy Efficiency Office
DEPARTMENT OF ENERGY

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ONE BRIDEWELL STREET

Heating

Two gas-fired boilers provide low temperature hot water to the various air handling units and to fan-coil units in perimeter offices.

The boilers are controlled from the electronic Building Energy Management System (BEMS), and are sequenced with a check to ensure that the lag boiler is not brought in unnecessarily for short periods. Optimum start of the plant is phased to stop the air handling units running until the heating is up to temperature: this saves electricity and prolongs the life of the boilers.

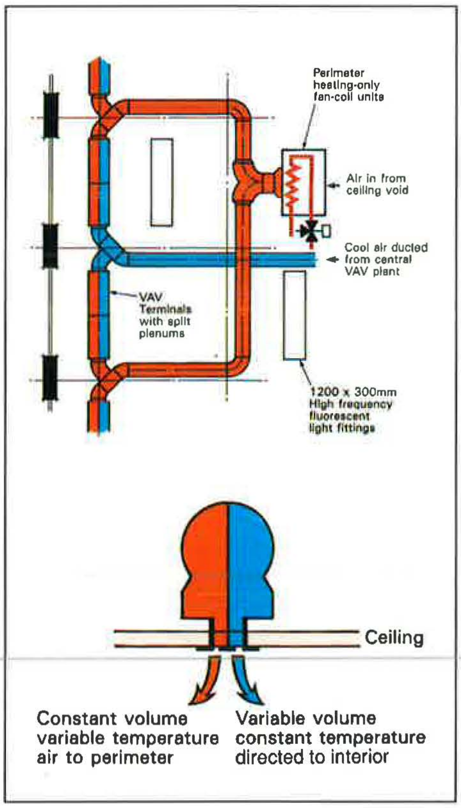
The boilers are switched off entirely in summer as there is no reheat load and domestic hot water is independent.

Office Ventilation and Air Conditioning

The main office areas are served by variable speed supply and extract air handling units with a mixing chamber in the roof plant room. Humidification in cold dry weather is by steam from packaged electrode boiler units. A Staefa Control Systems air quality sensor regulates the minimum amount of fresh air admitted.

Duct sizes are generous and pressure drops low, giving low fan energy running costs. Dampers to supply and return air branches to each floor allow air conditioning hours to be matched to local needs.

The Variable Air Volume (VAV) system provides conditioned air to mixing boxes and linear diffusers in the office ceilings. For most of the area the system is cooling only, with the amount of air delivered by each box under the control of local thermostats. The primary air temperature is scheduled against outside air temperature and reset by return air: it varies from typically 13°C in high summer to 23°C in mid-winter.



Perimeter systems in ceiling void

At the perimeter the VAV system is augmented by ceiling void-mounted heating only fan-coil units with central BEMS control and local room thermostats. The fan coils neutralise fabric heat losses and provide local control where there are cellular offices.

A similar but smaller VAV system serves the partners' wing, which consists largely of meeting rooms.

Central chilled water for the air conditioning plants comes from two reciprocating chillers with air cooled condensers which operate as required: normally only from May to September, and then often only in the afternoon.

Other Ventilation and Air Conditioning

Upper levels of the atrium are conditioned at low cost by exhaust air from the office system, transferred and warmed where necessary by fan-convectors which draw air from the ceiling voids of the adjacent office floors. In very hot weather, a roof fan exhausts air from the top of the atrium, but this is seldom needed.

The lowest level of the atrium has a small constant-volume air conditioning system to provide comfortable conditions for visitors and reception. A warm air system for the gymnasium is controlled by the BEMS to avoid unnecessary use.

Toilets and the small kitchens are on a separate supply and extract system.

Domestic Hot Water

Hot water comes from separate local electric water heaters in the toilet and kitchen areas on each floor and in the gym. The heaters are controlled by a channel on the ECS lighting control system to time schedules determined once demand patterns had been monitored by the facilities manager. The resulting on periods are very short.

HVAC Controls

The Staefa Building and Energy Management System (BEMS) provides all timing functions, most central temperature controls, and supervises dedicated electronic controls for the air conditioning plant. Room temperature control of VAV and fan coil units is local.

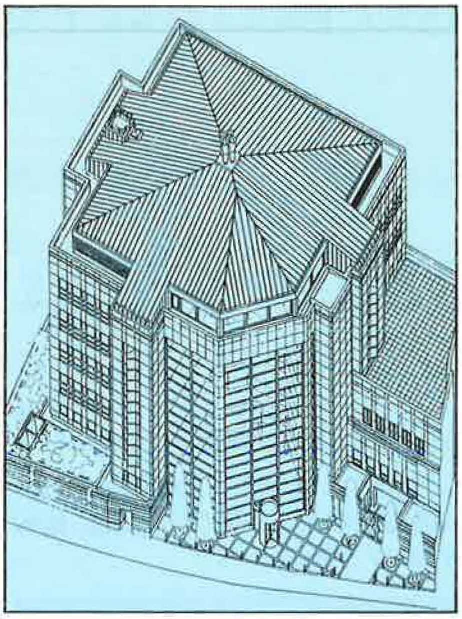
The building manager operates the system so that chillers and boilers never run simultaneously.

Air conditioning is often required until 8pm for late working on some floors but has not been found necessary for weekend users as the well insulated, compact building maintains a stable temperature.

Lighting

The windows are fairly small, affording daylight to perimeter offices only. The atrium is highly glazed and its adjacent circulation spaces are well daylit.

Office lighting is high efficiency fluorescent with good reflectors and high frequency electronic control gear. All decorative, circulation and WC lighting is miniature fluorescent, with some metal halide lighting in the atrium.



Lighting Controls

Lights are controlled centrally by a system provided by ECS Ltd. Various different "coding plugs" can be inserted into local controllers to designate the control channels to which the lights should respond, allowing the system to be altered easily as office layouts change. The controls currently work as follows:

- Occupancy lights in circulation areas and other selected safety points are switched on automatically during all normal occupancy hours on each floor.
- Working lights are switched on locally using hand-held infra-red controllers with magnetic backings so that they can be "parked" anywhere on the metal partitions. The system turns lights off at selected times at the end of the day, and at lunch in some areas.
- Solar control, switching perimeter lights according to daylight levels.
- Cleaners' lights, a reduced level for cleaners' schedules.

Atrium downlights are ECS-controlled to be on only when daylight is insufficient.

Car park lighting is time-controlled during peak hours and otherwise responds to movement sensors at the entrances.

The control system has proved effective except for the solar/daylight control, from which many occupants have opted out. This is not surprising as daylight levels are not very good and where there are cellular offices people tend to use manual controls quite well.

Other Systems

There is a small kitchen for hot drinks etc on each office floor, and two further domestic-scale kitchens with low-volume use, all with small dishwashers. There are two passenger lifts and one goods lift.

Building Team

Architects:	Alec French Partnership
Interior architects:	Austin-Smith Lord
M&E Engineering:	W S Atkins
M&E Installation:	Matthew Hall

Building Details

Pre-let office, completed	1987
Floors:	Ground +5 + roof plant room.
Gross floor area	6360m² 68480 ft²
Treated floor area	5020m² 54000 ft²
Nett floor area	3650m² 39260 ft²
Typical number of occupants:	310
Typical hours of use:	8.30am-6.30pm

or 8pm weekdays plus some weekend work.

Fabric

	U-values (W/m²K)
Walls (proprietary curtain wall)	0.6
Roof (stainless steel/insulated timber)	0.4
Windows (aluminium double glazed, with twin casements & clear glass)	3.0
Solar protection (mid-pane venetian blinds)	
Atrium (double glazed up to first floor only)	

Heating

Atmospheric gas boilers 2 × 400 kW

Constant-temperature LTHW to air handling units and ceiling fan convectors.

Electric heating for frost protection and door heaters.

Hot Water

16 local 3kW electric storage calorifiers under close time control by ECS system.

Ventilation and Air Conditioning

Variable volume air conditioning with perimeter fan-coils to offices: 200 kW 5-stage compression chiller with air cooled condensers. Tempered mechanical ventilation to toilets and gym. Constant volume air conditioning to lower part of atrium.

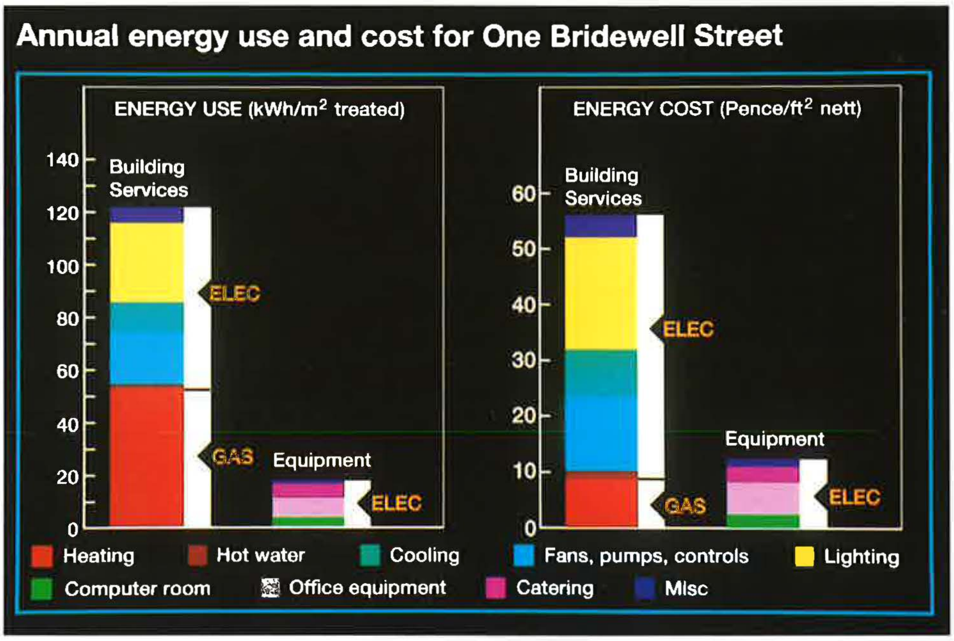
Lighting

Recessed 2 × 32 watt triphosphor fluorescent lights with high frequency control gear and low brightness louvres in offices to 350-800 lux 12 W/m².

Low energy miniature fluorescent lights to corridors, stairs and toilets. Good daylight to atrium greatly limits the use of its metal halide lighting.

Energy Management

Local pneumatic controls with central BEMS supervisory system and outstations by Staefa control systems. Automatic central lighting controls with hand-held local infra-red transmitters by ECS Ltd.



Analysis of Energy Use and Energy Cost

The diagrams show breakdowns of annual energy use and cost from January to December 1988. 441,000 kWh of electricity and 258,000 kWh of gas were used (86 and 53 kWh/m² of treated area) at a cost of £0.58 and £0.09 per ft² nett. The situation in 1989 was very similar. The building services energy consumption of 122 kWh/m² of treated area is about half the CIBSE Energy Code Part 4's "good" level for an air conditioned office.

Heating — 53 kWh/m² (9p/ft²)

This low figure reflects the compact building form, good energy management, air quality control, and the absence of standing losses in summer when the boilers can be switched off as they are not needed for domestic hot water. The study year was also mild (1799 degree-days).

Hot Water — 2 kWh/m² (1p/ft²)

This is a very low figure, even for local electric water heating. This arises as there is no restaurant and the energy management of the water heaters is tight.

Cooling — 12kWh/m² (9p/ft²)

Refrigeration energy use is fairly typical for a well managed building with modest heat gains and which makes good use of outside air for "free" cooling.

Fans, Pumps & Controls — 19kWh/m² (13p/ft²)

A very low figure for all-air air conditioning. The main VAV system operates at low pressures (450 Pa supply, 100 Pa extract) and the Heenan magnetic drives have high efficiency and power factors even at low load. All systems are well managed and tightly time-controlled including some duty cycling, and heating and cooling pumps are not allowed to operate simultaneously.

Lighting — 30kWh/m² (20p/ft²)

A low figure for a building which — except for the atrium — has only limited natural lighting: 50 kWh/m² or more is common for late 1980s air conditioned buildings. The main reasons for the improvement are:

- The high frequency fittings with good reflectors have an installed power of 12W/m² for 500 lux while standard fittings commonly use about 20W/m².
- Manual and automatic controls are good.
- The system as a whole is well managed.

Computer Room — 3kWh/m² (2p/ft²)

The minicomputer installation is small and is being phased out in any event as microcomputer networks take over.

Office Equipment — 8kWh/m² (5p/ft²)

The greatest part of this represents about 200 microcomputers, which are on for much of the working day, plus an average level of printers, photocopiers etc.

Catering — 5kWh/m² (3p/ft²)

There is only a modest requirement for private dining, snacks and hot drinks. There are no vending machines. The dishwashers (1 kWh/m²), although numerous, are only used once a day.

Miscellaneous — 7kWh/m² (5p/ft²)

This figure includes lifts (3kWh/m²), car park lighting (1 kWh/m²), telecom and security systems (2 kWh/m²) and the sauna. Steam humidification adds an extra 1 kWh/m².

User Reactions

One Bridewell Street provides an attractive workspace which appeals to occupants, with all tenant organisations reporting that staff morale has improved. The success is attributable to a combination of good design and good and highly responsive management.

The building was very comfortable during the hot summer of 1989, while maintaining a low energy consumption for cooling, and became known as a haven of comfort within the locality.

The lighting control system provides a considerable degree of landlord's control which can sometimes be resented by sub-tenants. But here helpful and responsive facilities management has tackled the initial problems — such as automatic OFF sweeps in the middle of the day, which have been discontinued — and the tenants now see the automatic controls as a benefit. The hand-held local controllers are popular and also mean that wiring does not have to be altered when office layouts change.

One particular operational problem has had to be carefully managed. With the efficient lighting and lower than expected heat gains from office equipment, the VAV core cooling system does not have all that much cooling to do.

To avoid over cooling or under ventilation, it has therefore been necessary to schedule the supply air only a little below room temperature. Any further high concentration of equipment accumulated in one part of the building may therefore require the supply air temperature to be lowered.

General Appraisal

One Bridewell Street has met the brief of providing a high profile regional headquarters with a high quality of internal environment. Energy costs are also very low for an air conditioned building. The building is managed with the occupants' requirements as the prime concern, and the plant and its associated controls are seen as tools to achieve the required conditions at minimum cost.

The office air conditioning, although fairly conventional, operates at low pressures and is carefully designed, controlled and managed, which leads to a considerably lower fan energy consumption than in most comparable buildings. The dampers on each floor and the economical manual and automatic operation of the plant are also managed to meet occupants' requirements without any uneconomic over supply of ventilation, heating or cooling, and with automatic air quality sensing.

The lighting is very economical for what is largely a permanently artificially lit building, except in the daylit atrium and a few perimeter offices. There are three main reasons for this:

- Efficient lamps and luminaires are installed throughout, giving a low installed power. This also means there is less heat to be dissipated.
- An effective combination of manual and automatic controls gives occupants choice while limiting waste, and many people using computer screens prefer to work with only some of the lights on.
- Good management, which ensures that the controls operate effectively without adverse user reaction.

Energy use and CO_2 Savings (Degree Day adjusted figures)

	Energy kWh/m² treated			CO_2 Savings kg/m²
	Case Study	Typical	Reduction	
Gas	70	222	152	30
Electricity	86	201	115	95

The table above compares fuel and electricity use with a typical medium sized air conditioned office (Energy Consumption Guide No. 19). It also shows how the implied savings translate into reductions of CO_2 emissions. If 10% of all UK offices were to save CO_2 on this scale, it would achieve a reduction of 1 million tonnes of CO_2 annually.

Main Conclusions

By attention to every stage from inception through to management, One Bridewell Street demonstrates that high comfort standards and modest running costs can be obtained using proven and readily available technology, without any particularly remarkable energy saving architectural or engineering features. For instance:

- Insulation standards are not exceptional.
- Fan-power is low because the air systems are well engineered.
- Installed lighting power is low because high efficiency fittings were used and circulation areas benefit from daylight.
- The energy-wasteful complications which can often arise from using central boiler plant for domestic hot water have been avoided by heating the hot water independently.
- Controls are sophisticated yet standard and easily adapted, with the BEMS operating at a supervisory level only.

The high frequency fittings and good lighting controls, although more expensive items than normal, probably paid for themselves before completion by simplifying the electrical installation and the associated design information. Tenants are now enjoying further savings because internal alterations do not require physical changes to the wiring system.

In conclusion, what really distinguishes One Bridewell Street from many similar buildings is not any particular innovation, but a sensible use of available technology, together with a high standard of management which aims to satisfy the occupants in the most efficient and economical manner.

While much scope remains for reducing office energy requirements still further using more advanced design and technology, the lesson is first to see how far you can get first by keeping things simple and doing them well.

On a cautionary note, operational experience suggests that low and variable heat gains from lighting and uneven office equipment loads (which frequently average only around one-third of nameplate ratings) may call the widely used cooling only VAV core systems into question. While the problem here has been manageable, the issues raised should be carefully considered in the design of new air conditioning systems.

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 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.

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