#6156

February 1991

BEST PRACTICE PROGRAMME

Good Practice Case Study 19

South Staffordshire Water Company, Green Lane, Walsall.
New offices designed to maximise natural lighting and minimise heating requirements.

The Project

At Green Lane, the South Staffordshire Water Company (SSWC) inherited some deep air-conditioned offices which their staff did not like. So when the time came for a new building, SSWC wanted views, natural light, natural ventilation and user control. Databuild Ltd were appointed to advise on the use of passive energy systems to maximise comfort and amenity and minimise fuel costs.

The reclaimed mining site dictated a compact form around a central structural core. An inverted pyramid form under a pitched roof was finally chosen. Walls, roofs and floors are very well-insulated (U-values 0.2, 0.3 and 0.3W/m^{2}K). Heating is by perimeter radiators.

Large windows and high ceilings make the most of natural light and ventilation. Overhangs, an internal/external "light shelf" and internal blinds limit glare and summertime temperatures but let winter sunshine in, which also reduces heating requirements. Electric lighting is both efficient and electronically-controlled.

PVC tilt-and-turn windows with low-emissivity glass and high-performance weatherstripping have a U-value of 1.6 W/m^{2}K, about half that of conventional double-glazing.

The Result

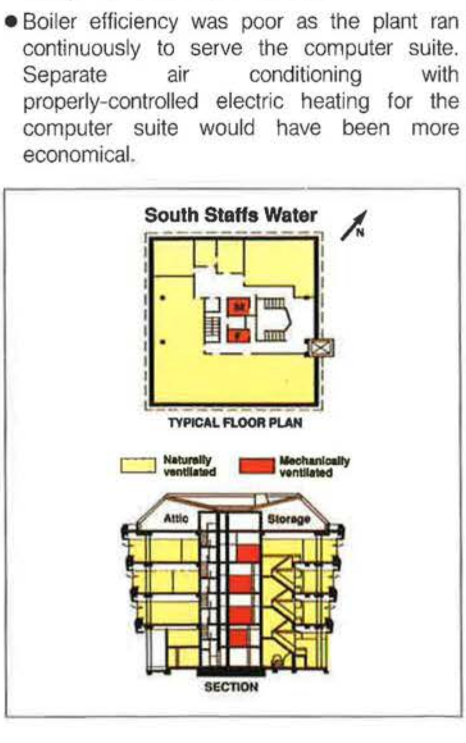
Monitoring under the Department of Energy's Energy Performance Assessment (EPA) programme has confirmed that the main perimeter offices have particularly low energy consumption and costs.

- **Building designed with passive solar features.**
- **Good natural lighting with summertime solar protection.**
- **First UK commercial use of low-emissivity double glazing.**
- **Low installed lighting power with automatic energy management controls.**
- **Acceptable summertime temperatures with natural ventilation only.**

Daylight quality is good, lighting costs low, heating requirements small, and user reactions favourable. Overheating has not been a problem, even in the hot summer of 1989.

However, this good baseline has brought other aspects of the design into sharper focus and revealed scope for yet more improvement. For example:

- Some of the low energy potential was undermined by shortcomings in system and control design and operation.
- The electronic energy management system was too complex for the size of building (though things should get better once the system has been extended to other buildings on and off the site.)
- Lighting in corridors, WCs etc is much less energy-efficient than in the offices.
- Boiler efficiency was poor as the plant ran continuously to serve the computer suite. Separate air conditioning with properly-controlled electric heating for the computer suite would have been more economical.



ENERGY

EFFICIENCY

IN OFFICES

Energy Efficiency Office
DEPARTMENT OF ENERGY

SOUTH STAFFORDSHIRE WATER COMPANY

Heating

Three Hamworthy UR modular gas boilers in an adjacent building supply low temperature hot water (LTHW) to two separate circuits:

Temperature-Compensated, feeding perimeter radiators. Flow temperature is varied in accordance with outside temperature, via a 3-port valve. Individual radiators also have thermostatic valves to permit local control and make use of "free" solar and internal heat gains. Each facade on each floor is also separately controlled from room temperature via motorised valves in the central core.

Constant-temperature, serving the toilet air-handling plant, radiators in internal and ancillary areas, reception fan-convectors, and domestic hot water calorifier.

The constant-temperature circuit also feeds two systems outside the boundary of the new building - ventilation for main kitchen/restaurant and air-conditioning for the computer suite.

The EPA monitoring was primarily concerned with the perimeter offices so only the compensated circuit was comprehensively heat-metered. However, only about one-quarter of the heat took this route and, in hindsight, measurement of all energy flows from the boilers would have been very informative.

The constant-temperature circuit was particularly uneconomical: hot water circulated in it continuously to be available for the computer suite, incurring standing losses throughout the system and reducing the overall efficiency of the boilers. This is a common problem where the same systems serve both buildings and computer uses. For most of the time an efficient computer air-conditioning system should have required no heat at all!

Domestic Hot Water

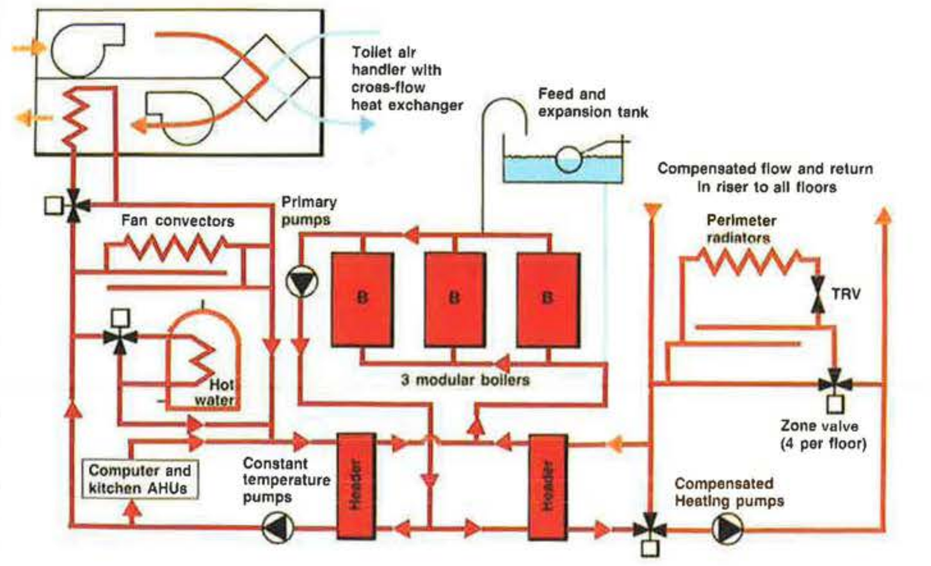
The hot water system is conventional, with a calorifier in the boiler room and secondary circulation to the new building and up its central core. A self-contained single-purpose system would probably have been more economical.

Ventilation

Office ventilation is natural via tilt-and-turn windows. Toilet ventilation is by a packaged supply/extract plant in the roof plant room with LTHW heater battery and cross-flow heat exchanger.

Lighting

The building has a north-south diagonal in order to allow some sun into all the windows. A complex window design with overhangs and internal and external "light shelves" cuts solar heat in summer and evens-out the distribution of daylight and sunlight.



HEATING SCHEMATIC

The smooth gradation of light feels comfortable and stops people wanting electric lights on to compensate for an excessively bright perimeter. Low winter sun through the upper parts of the window which do not have blinds occasionally causes glare.

Office electric lighting is by 600mm square fittings with high-efficiency reflectors and three fluorescent tubes each. The inner tube and outer pair are independently controlled to provide different levels of top-up. Desk lights are available but not very extensively used.

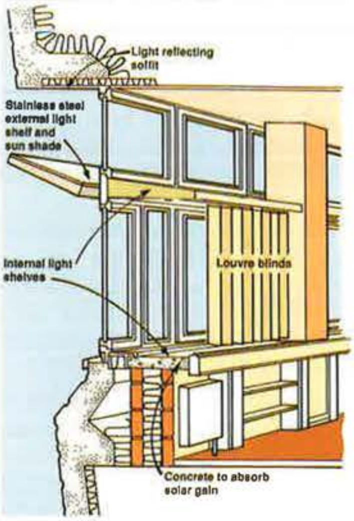
Controls

All control functions are from a central Landis and Gyr Visonik Electronic Energy Management System (BEMS), including the photoelectric and timed lighting controls (with user over-ride switches). The system has proved to be too elaborate for the size of building: SSWC has not found it cost effective either to use their own staff or to pay others to get the most out of it.

Perhaps too much of the BEMS's capacity is devoted to local control and not enough to the central plant. For example, each light switch activates a status point (giving an inconvenient time delay of up to 30 seconds while the BEMS decides what to do), while the boilers and primary circulation runs for 24 hours a day whether or not anything wants them. Much care and thought is required for a control system to be really effective and matched to the needs of the users.

Catering

The new building has three vending machines, plus a small kitchen on the third floor with high volume supply and extract ventilation to commercial catering standards. Since meals were to be served only once or twice a week, the supply air plant had an electric heater battery and local control with automatic OFF at the end of the day. In fact, the kitchen is used daily for making coffee, and the main plant runs, expensively heating a lot of air only to extract it again. A low-powered extract-only system would be more economical for this level of usage.



SOUTH STAFFS WATER FACADE DETAIL

Building Team

Architects:	Harry Bloomer Partnership
Services Engineers:	King Cathery Partnership
Energy Consultants:	Databuild Ltd
Builder:	Linford-Bridgman
Mechanical Installation:	Rosser & Russell
Electrical Installation:	Balfour Kilpatrick

Building Details

Purpose-built office, completed 1985 Floors: Ground + 3 office + part mezzanine and unheated attic.

Gross floor area	3525m² 37940ft²
Treated floor area	2860m² 30750ft²
Nett floor area	1770m² 19080ft²
Typical number of occupants:	160
Typical hours of use:	8am-6pm weekdays

Fabric	U-Value (W/m²K)
Walls (brick clad concrete panels, blockwork and insulation)	0.2
Roof (including attic) and floor	0.3
Windows (PVC double low-emissivity)	1.6

Solar protection: overhangs, light shelves and internal vertical louvre blinds.

Heating and Hot Water

Modular gas boilers	3 × 80kW

Compensated — circuit for perimeter radiators with four zones per office floor, plus local thermostatic radiator valves. Optimum start/stop for occupancy hours.

Constant-temperature circuit for toilet air handling unit, reception fan convectors and domestic hot water calorifier for the Case Study building, plus the adjoining restaurant and computer suite.

Boilers run throughout the year for domestic hot water and the computer suite.

Ventilation

Mechanical ventilation (with cross-flow heat exchanger) to internal toilets only, plus kitchen extract system. The computer suite's air conditioning was not monitored in detail and so the computer area is excluded from the Case Study, although it has affected heating plant efficiency.

Lighting

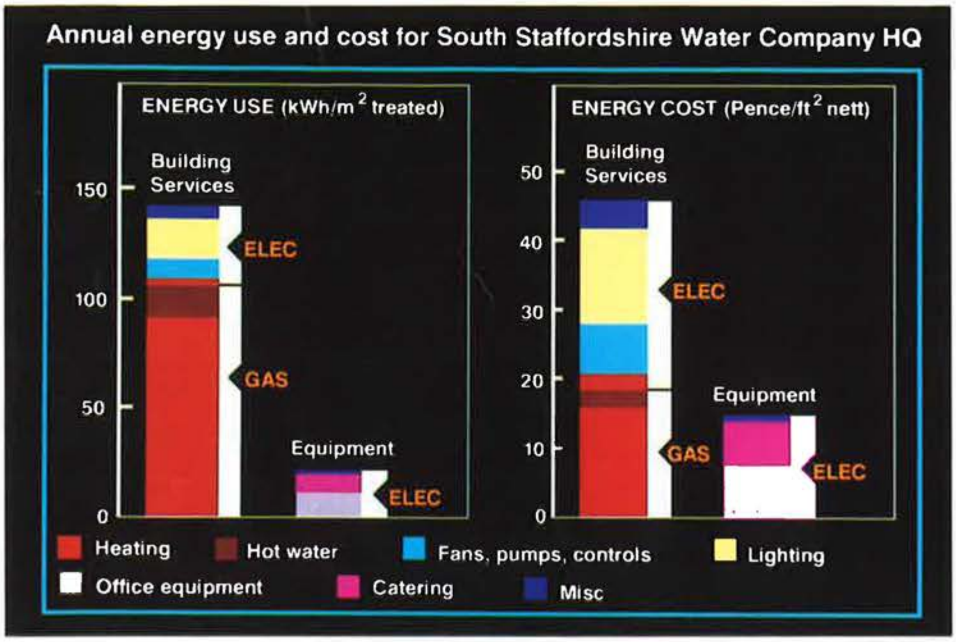
Well-controlled daylight to perimeter.

Recessed Fluorescent lights	350 lux
Office installed load	10 W/m²

16 Watt task lights available in offices.

Energy Management

Central control and monitoring by BEMS, including heating zone and lighting control.



Annual energy use and cost for South Staffordshire Water Company HQ

Analysis of Energy Use and Energy Cost

The diagram above shows the breakdown of annual energy use and cost.

From March 1987 to February 1988 (2452 degree days) the building (excluding main restaurant and computer suite) consumed an estimated 303,500kWh of gas and 157,700 kWh of electricity, costing £3500 and £7900 respectively: 18 and 41 p/ft². The total of 161 kWh/m² of treated area is well within the CIBSE Energy Code Part 4's "good" category for a naturally-ventilated office of this size. If the area of the unheated attic store was included, energy use would drop to 136kWh/m².

■ Heating 93kWh/m² (3 electric)

The monitored LTHW consumption for the perimeter offices was just under 50kWh/m². Rooms on the constant temperature system — particularly the toilets and reception area — required more heat, raising the overall heat metered consumption to 59kWh/m². Owing to the sharing of boiler plant between the new building, the computer suite and the restaurant, the exact boiler efficiency for heating the building is not known. Assuming a 65% efficiency, typical for boiler plants of this type, annual gas consumption of 90kWh/m² is estimated. Had the boilers been devoted to space heating alone 75kWh/m² could well have been achieved. The electricity is used by the kitchen ventilation heater battery.

■ Hot Water 16kWh/m²

Estimated gas consumption for hot water is disappointingly high in spite of the water-conserving spray taps. With the central system linked to the heating boilers and fairly long pipe runs, standing and circulation losses dominated.

■ Fans, Pumps & Controls 9kWh/m²

Consumption is approximately equally divided between the three items. Although fairly small, the figures are high for a naturally-ventilated building owing to the complex control system and long running hours of pumps and fans.

□ Lighting 18kWh/m²

Lighting energy consumption is very low for open offices and shows the effective use that can be made of daylight with good window design and appropriate automatic controls. The main stairs and associated copying, vending and waiting areas are also well daylit.

The monitored annual consumption for the ceiling lighting was 50,670kW/h, plus an estimated 2,250kWh for task and emergency lights. A disproportionately high part of this occurred in the non-office areas: corridors, internal stairs, toilets and internal rooms. In these areas not only are lighting hours longer but the installations are less efficient.

□ Office Equipment 11kWh/m²

The amount of office equipment and its energy use is about average.

■ Catering 8kWh/m²

Most of this is for three vending machines which are left on constantly to avoid the ingredients congealing. The rest is for the third-floor kitchen.

■ Miscellaneous 6kWh/m²

Just under half is attributable to the lift and the rest to external lights, fountains, and lights in the attic store room. The telephone exchange — in an adjacent building — serves the whole site and is not included.

Interior view showing solar protection

User Reactions

An EPA questionnaire survey in March 1988 showed that the building was liked by the majority of its occupants, although no outstanding feature was recorded.

Most people found summertime temperatures satisfactory but 30% mentioned feeling cool in winter. Although measured temperatures in some zones were occasionally low in the early morning, many of these comments probably stemmed from radiators being cool to the touch even though the building was up to temperature.

Initially the reception area was cold — a common problem — and additional fan-convector heaters were fitted. Natural buoyancy within stairwells and atria can often draw in more cold air at low level than designers anticipate.

There were a number of complaints about ventilation: the tilt-and-turn windows did not offer sufficient fine adjustment of air flow.

Of the specifically passive solar features, about 80% were happy with the window design generally, the light shelf, the overhanging eaves, and the deep window cills. However, there were adverse reactions to:

- The blinds which were inconvenient to operate, having retraction and tilt controls at opposite ends and often being obstructed by books on the cills.
- Glare from the upper windows, which did not have blinds and let in low-angle winter sun. The main problem was reflections in VDU screens.
- The automatic lighting controls which were thought to operate capriciously and be difficult to over-ride manually owing to the time delay between switch operation and response.

General Appraisal

The passive design features: planning and orientation, good insulation, high performance glazing, daylight, natural ventilation and solar heat gain control have all worked well and produced offices with a low energy demand. The new building meets SSWC's objectives and confirms that air-conditioning was not necessary for their requirements.

The lighting energy use is low in spite of several drawbacks, including:

- One "safety" lamp in each fitting being switched on for all the working day, which was often unnecessary. The circuits are now being disconnected.
- Photoelectric controls difficult to set, requiring screwdriver adjustment in a remote location. Software adjustment via the BEMS would have been better.
- Higher-than-necessary installed power in internal areas where running hours were longer than in the carefully-studied daylit offices.

Heating energy use, although quite low, is disappointing in relation to the very small actual requirement in the offices. The heating plant and its operations were not matched to the low heating needs and the BEMS concentrated too much on room rather than plant control. Perhaps the main problem was to use a single constant-temperature circuit to supply a number of uses, including the computer suite which — at least in theory — could require heat at any time.

The pitched roof design created a very useful 520m^2 of attic storage. Being unheated and seldom occupied, with lighting on interval timer controls, this does not fall within the definition of treated area. But with insulation under the tiles, its temperature remains fairly stable throughout the year, and accommodates records which would otherwise have to be housed more expensively elsewhere.

Main Conclusions

SSWC demonstrates that thought put into plan section and orientation, and using passive solar design employing good daylight, insulation, and solar control can produce a satisfactory building shell with low energy demands.

Energy consumption and costs are low by current standards, but they fell short of design estimates because the building services and controls did not meet the reduced energy demand as efficiently as had been expected. Similar problems arise in many buildings.

Features common to SSWC and several other Case Studies include:

- As the main design becomes lower-energy, formerly insignificant details (like standing losses and the lights in the corridors) increase in relative importance.
- Systems undertaking a range of different duties (in this instance common boiler plant for heating, hot water, and computer air conditioning), may operate inefficiently on a year-round basis: separate systems are often preferable.
- Computer suite air-conditioning regularly costs more to run than it should because everything stays on "just in case". Energy Managers who are skilled and brave enough to challenge this will often reap large savings.
- Controls should be effective, well designed, clear to understand and simple to use. This applies as much to the humble light switch and window catch as to engineering systems controls.
- Computerised Building Energy Management Systems are no exception and have to be carefully engineered and user friendly. Too many features may themselves become a management problem and add to maintenance costs, particularly in smaller buildings which do not have resident service engineers.

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

Exterior view showing window design

All Case Study analyses in this series are based on at least one year's measured fuel consumption and cost. Further breakdowns 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 co-operation of Databuild Ltd. and the owners, designers, managers and the occupants of the Case Study building is gratefully acknowledged.

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