November 1991

BEST PRACTICE PROGRAMME

5754

Good Practice Case Study 105

Tektronix U.K. Ltd.
Marlow
Buckinghamshire

Main building

- **Electronic equipment business**
- **7432m^2: 75% offices/equipment servicing, 25% warehouse**
- **Owner occupier via developer**
- **Part air conditioning**
- **Gas heating with zone control**
- **Low wattage fluorescent/mercury discharge lighting**
- **Refurbishment with heat pump air conditioning and lighting control**

ENERGY EFFICIENCY IN MIXED USE BUSINESS SPACE

Background

Tektronix U.K. Ltd is a wholly-owned subsidiary of a USA company, primarily concerned with the marketing and after sales servicing of electronic equipment. The company owns the building which is occupied by approximately 200 employees.

The total floor area is 7432m^2, 80000ft^2. The majority of the floor space on two-storeys (75%, 5574m^2, 60000ft^2) provides general office accommodation, a computer suite and a service area for the repair of electronic equipment. The remaining warehouse area (25%, 1858m^2, 20000ft^2) is used for equipment storage and dispatch.

Arlington Property Developments Ltd. developed the Globe Business Park and initially employed Covell-Matthews to undertake the non-detailed design of the building. Tektronix produced an outline brief, stating the functional requirements of the buildings, which was the basis for a design and build package by Taylor Woodrow.

The building was completed in October 1984 and the total building costs were approximately £7 million (£942/m^2), including £2 million for the building services (£269/m^2).

Summary

The total annual energy consumption for the building in 1989/90 was 1.901 x 10^6 kWh at a cost of £66090. The normalised energy use is equivalent to 215 kWh/m^2, placing the building in the EEO 'good' energy rating category with a 26% saving over an average equivalent part air conditioned office/factory building. The contribution of general power is high due to the electrical servicing activity. The space heating energy use at 84 kWh/m^2 is relatively low, reflecting suitable fabric insulation and heating controls. Lighting energy use (58 kWh/m^2 for the main building) is high, and could be reduced by better use of the available daylight.

The indoor environmental conditions are satisfactory for the occupants and business requirements, although uncomfortably high summer time temperatures were experienced in some non air conditioned offices on the first floor.

Since completion of the Case Study, services on the first floor have been refurbished with installation of an efficient air conditioning/heating system using heat pumps. In addition, a lighting control system has been provided using daylight and zone sensors and will give savings for both lighting and air conditioning.

Tekservices area

Office area

BEST PRACTICE PROGRAMME

Energy Efficiency Office
DEPARTMENT OF ENERGY

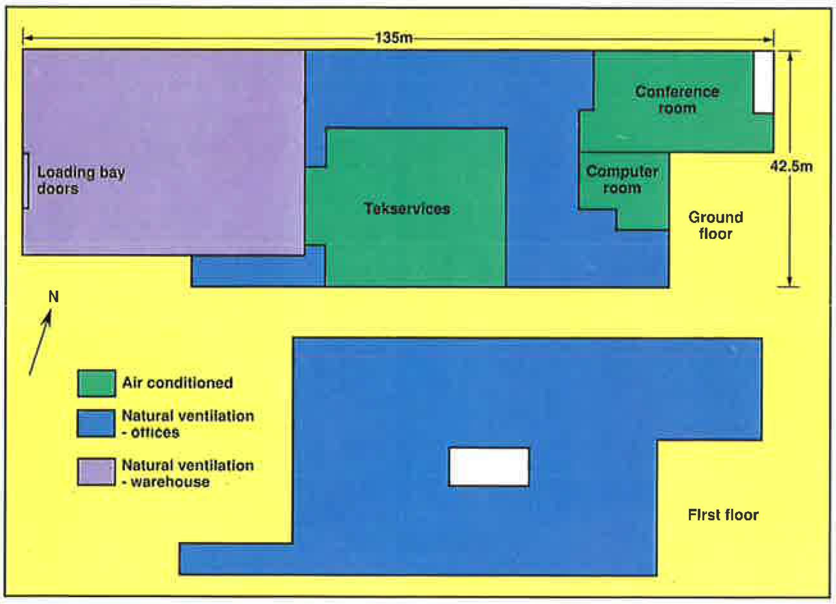
(R5)
C1/Sfb 1976 517 (Y2)

TEKTRONIX UK LTD

Building Design and Construction

The main building, comprising offices, a computer suite and a service area is predominantly open plan, with low level partitions creating both individual and group working areas. Generally, a traditional construction was employed to achieve insulation standards mainly to the then current Building Regulation requirements only, in order to minimise the construction costs, although double glazing was used. The ratio of ground floor area to wall area is 2.24:1.

The wall construction to the ground floor of the main building is of brick-cavity-concrete block with 50mm mineral wool insulation in the cavity and the U-value is better than the then current Building Regulations. The first floor utilises a glazed curtain walling system consisting of sealed double glazed units with an anti-sun inner pane to reduce solar gain. Internal blinds are also installed on south facing windows. The roof is flat with rigid foam insulation board on a profiled metal deck, finished with three layers of roofing felt. The building has an uninsulated concrete ground floor.



Floor plan showing air conditioned and naturally ventilated areas

Warehouse exterior

The warehouse is a single storey, double height construction. The wall construction is profiled metal cladding with integral insulation. Concrete blockwork forms a double skin construction from the ground to a height of approximately 2m. Windows are louvred single glazed units. The warehouse roof is metal clad with an insulated lining board. Double skinned plastic rooflight strips cover about 10% of the roof. There are two loading doors of 3 x 2.5m.

The fabric design U-values are:

	Main building	Warehouse
	U-value (W/m²K)	
Walls	0.49	0.6
Glazing	2.80	5.6
Roof	0.60	0.6
Rooflights	—	3.0

For the main building the wall U-value selected was 18% lower than the then current Building Regulation standard of 0.6 W/m²K.

Building Services

Heating Systems

Space heating in the main office area is provided by sill-line natural convectors and a small number of conventional radiators. These are heated by two floor standing gas-fired boilers, each of output 325 kW. Primary control of the heating system is provided by an optimiser unit, with local thermostats and motorised valves giving zone control. The warehouse is heated by gas-fired warm air heaters under thermostatic and time control. The loading doors are open for about 40 minutes per day.

Air Conditioning Systems

About 25% of the total floor space is air conditioned. Separate dedicated plant serves each of three areas: the computer rooms, service area and conference/demonstration rooms.

The computer rooms are serviced by three modular air conditioning units with full temperature and humidity control. The service area has full temperature control and the capacity to dehumidify only should the humidity reach 70% rh. The conference rooms are temperature controlled by variable air volume type plant.

Domestic Hot Water

The domestic hot water service is provided by the two gas-fired heating boilers. During the summer months one boiler is shut down and the remaining boiler maintains the domestic hot water service.

Lighting

Lighting in the main building is by slimline low wattage (mainly 36 W) fluorescent tubes housed in recessed luminaires with prismatic diffusers. Warehouse lighting is provided by high bay mercury discharge lamps (30 x 400 W) and fluorescent tubes.

Daylighting is provided by large areas of glazing to the main building, which also has a light-well on the first floor. The warehouse has a small number of rooflights. The first floor overhangs the ground floor providing a degree of shading.

Warehouse interior

Energy Use

The building is occupied for five days/week with official working hours of 0845 to 1700. However, in practice occupancy is more likely to be from 0730 to 1900. This pattern of building use gave annual energy consumptions for the year ending July 1990 of:

gas	25700	therms	(101 kWh/m^2)
electricity	1.149×10^6 kWh		(155 kWh/m^2)

The total annual energy consumption was 1.901×10^6 kWh (256 kWh/m^2), equivalent to 1104 tonnes CO_2, and disaggregated as shown in the Table and Figures. The consumptions were fairly typical of previous years.

Gas is used for space heating, domestic hot water and cooking. Space heating is the major user (83% of gas), and there is a marked seasonal variation in gas consumption as would be expected. In summer, gas is used for domestic hot water and cooking only. In winter, the correlation coefficient between gas consumption and degree days was 0.83, showing good control.

For electricity, general power is the major user (47% of electricity), reflecting the use of the building for electrical servicing; there is little overall seasonal variation. The lighting load also remains fairly constant between summer and winter. During the winter, the air conditioning load is reduced by almost half due to the effect of climatic conditions.

Energy Costs

The annual energy cost was £66090 (£8.88/m^2), comprising:

gas £8647 electricity £57443.

Although gas consumption was 40% of the total energy use, because of the tariff structure it accounts for only 13% of the total cost.

Normalised Performance Indicator

Comparison with the EEO performance ratings for buildings energy use (excluding 'process' use) required normalisation of the space heating energy use to 2462 degree days and then normalisation of the adjusted 'buildings' energy use to 2600 occupancy hours. The environmental conditions for the warehouse resemble those for a factory rather than for a typical warehouse. The synthetic ratings for a 'good' part-air conditioned office/factory were computed in proportion to floor area from the component ratings (Energy Efficiency in Buildings – Offices/Factories and Warehouses, EEO 1990).

These gave the following comparison of annual ratings:

Normalised Performance Indicator	215 kWh/m^2
EEO 'good' equivalent	<238 kWh/m^2
EEO 'average' equivalent	290 kWh/m^2

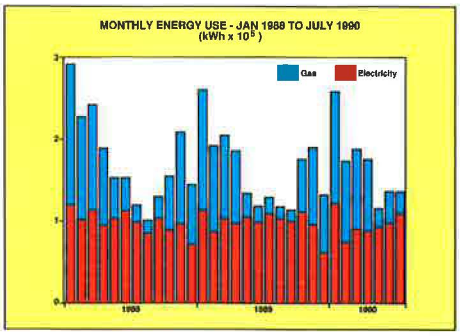
Disaggregated use of delivered energy

June 1989 to July 1990 (1689 degree days)

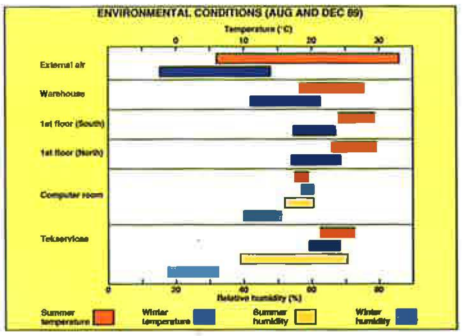
Occupancy: 2875 hours

Gross floor area basis for whole building or applicable areas only*

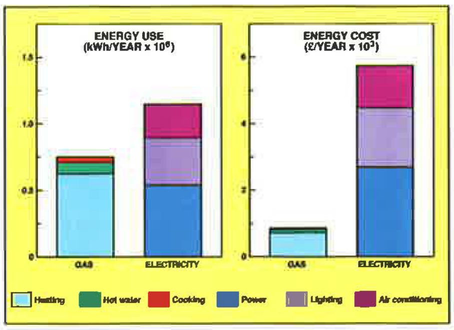
	Energy Component	Annual Energy Use kWh	%	kWh/m^2
Gas	Space heating			
	Office/service areas	458500	24.1	82*
	Warehouse	166800	8.8	90*
	Total space heating	625300	32.9	84
	Domestic hot water	89500	4.7	12
	Cooking	37600	2.0	5
	Total gas	752400	39.6	101
Electricity	Lighting			
	Office/service areas	320570	16.8	58*
	Warehouse	35620	1.9	19*
	Total lighting	356190	18.7	48
	Air conditioning	252780	13.3	136*
	General power (building)			
	Office equipment	89180	4.7	16*
	Fans, pumps, controls	28870	1.5	5*
	Total general power (bldg.)	118050	6.2	16
	Total electricity (bldg.)	727020	38.2	98
Total building		1479420	77.8	199
	General power ('process')	421980	22.2	147*
	Total general power	540030	28.4	73
	Total electricity	1149000	60.4	155
Total building and 'process'		1901400	100.0	256



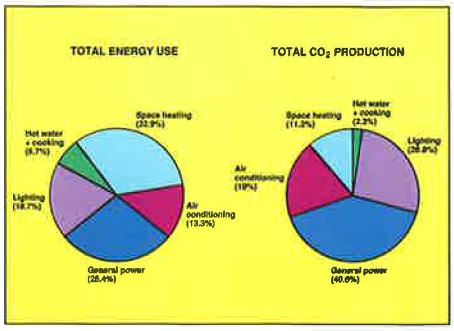
Monthly energy use — Jan 1988 to July 1990 (kWh x 10^5)



Environmental conditions (Aug and Dec 1989)



Energy use (kWh/year x 10^6) and Energy cost (£/year x 10^3).



Total energy use and total CO_2 production.

Environmental Performance

As a result of employee preference, winter working temperatures were high: the office/servicing areas could exceed 23°C and did not fall below 17°C overnight. In summer, high temperatures up to 29°C were recorded for the first floor offices. The air conditioned computer room maintained constant temperatures to within 1°C and the servicing area relative humidity was held below 70% as required.

Although illumination levels were satisfactory, there were reported problems with glare on VDU screens.

User Reactions

Energy efficiency was not emphasised at the design stage but with hindsight the owner-occupier would give this greater priority. Cost constraints were imposed by the parent company and the developer and the occupier had little input to the detailed specification.

The building is considered reasonably energy efficient but would be improved by more sensible light switching arrangements, separating the domestic hot water from the space heating system, and heat recovery from the computer room cooling systems. Retrofit air conditioning was proposed to overcome the summer overheating in the first floor office areas. Because an extended pre-heat period is not available on the optimiser controller, the desired working temperatures may not be reached when occupancy commences on cold Monday mornings.

General Appraisal

The correlation between gas consumption and degree days indicates the space heating controls can respond satisfactorily to weather conditions. The space heating energy use was low, although there were only 1689 degree days in the year monitored compared with the area average of 2115 degree days. However, an overall reduction of 1-2°C in working temperatures would save at least 10% and there is further potential from reducing the night set back temperature. A separate lower rated domestic hot water boiler would be a more efficient option for the summer.

The solar control film on the glazing and the internal blinds to the south side were insufficient to prevent summer overheating. The situation was not helped by the large expanse of glazing (66% of first floor south wall), the lack of cross ventilation because of the deep plan, and the lightweight flat roof and wall construction. Consideration of summer time temperatures at the design stage is clearly important if overheating is to be avoided without air conditioning. External shading and reduced glazing areas, for instance, would have contributed to providing a more comfortable working environment.

Air conditioned conference/demonstration room

The lighting energy use in the office and service area is comparatively high, despite the use of slimline low wattage fluorescents, good daylighting to the perimeter, and the incorporation of a light-well on the first floor. Switching arrangements are not sufficiently flexible, convenient or clearly labelled, and as a consequence lights tend to be left on all day. A better lighting strategy, so that perimeter lights could be readily turned off, would offer scope to reduce energy costs.

POST CASE STUDY REFURBISHMENT

Since completion of the Case Study the owner occupier has refurbished first floor services with installation of air conditioning and a lighting control system.

- The air conditioning uses an eight zone, variable volume and temperature system incorporating roof-mounted heat pumps. The cooling provided will deal with summer overheating and since heating can also be provided the system will assist building warm up on cold mornings and overcome the optimiser pre-heat problem.
- The lighting control system is based on sensing both available daylight and zone occupancy. It will provide energy savings on both air conditioning and lighting.

GENERAL LESSONS AND RECOMMENDATIONS

1. Specify and consider energy efficiency more fully at the design stage in an integrated manner. This can improve comfort, lower running costs and obviate the need for expensive refurbishment and retrofit.
2. Use U-values better than required by Building Regulations as well as double-glazed windows and rooflights. Assess summer working temperatures and cross-ventilation requirements, especially for a deep-plan building, in relation to the amount of daylighting provided through windows and light-wells. As well as anti-sun window panes, first floor overhang shading and internal blinds, consider additional measures such as external shades. Be aware of problems such as glare on VDU screens.
3. Gas-fired modular boilers with an optimiser and zone control provide the basis for a suitable heating system, but greater efficiency is possible through use of condensing boilers and a separate small boiler for domestic hot water. Gas-fired warm air heating with controls is suitable for warehouse areas.
4. Consider the need for separate plant to meet the varying requirements for air conditioning in areas with different types of activity, including modular units for a computer room and the viability of heat recovery, eg by heat pumps.
5. Install efficient fluorescent and high bay lamps, but also provide well-labelled flexible light switching arrangements which permit perimeter lights to be turned off easily.
6. Where possible, obtain energy savings from the use of lower set points for working temperatures and night set-back temperatures.

ACKNOWLEDGEMENTS

The Case Study has been prepared by Wimpey Environmental Limited. The assistance of the owner-occupier and the architect is gratefully acknowledged.

Further information on this or other buildings-related projects, please contact: Enquiries Bureau, Building Research Energy Conservation Support Unit (BRECSU), Building Research Establishment, Garston, Watford, WD2 7JR. Tel No. 0923 664258. Fax No. 0923 664097.

For further information on industrial projects, please contact the Energy Efficiency Enquiries Bureau, Energy Technology Support Unit (ETSU), Building 156, Harwell Laboratory, Oxon OX11 0RA. Tel No: 0235 436747. Telex No: 83135 . Fax No: 0235 432923.

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